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The steering Committee of the Seventh National Conference on Waste Management in Canada wishes to record it's appreciation of the efforts of the panelists for preparing the outlines of their papers and their subsequent delivery and to the panel moderators for guiding panelists and audience during the conference sessions.

Le comité d'organisation de la 7ième Conférence Nationale sur la Gestion des Déchets au Canada aimerait noter son appréciation auprès des conférenciers pour la préparation de leur présentation ainsi qu'aux modérateurs pour leur aide soutenue lors du déroulement de la conférence.

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Transport Canada - Overview

Duncan Ellison, Transport Canada

Paper unavailable at time of printing

RÈGLEMENT SUR LE TRANSPORT DES MARCHANDISES DANGEREUSES

DÉCHETS DANGEREUX

par: Antoine Dionne
Direction des programmes industriels
Environnement Canada

Pour faire suite à l'exposé de mon collègue, j'aimerais vous entretenir des particularités du Règlement sur le Transport des Marchandises dangereuses (TMD) en ce qui regarde les déchets dangereux. En effet, les déchets dangereux présentent un aspect spécial du fait qu'ils sont des matières inutilisables, donc sans valeur pour personne, augmentant ainsi les chances qu'ils disparaissent subreptissement dans l'environnement. Des données en date de 1980, indiquent que l'Industrie canadienne produit chaque année environ trois millions de tonnes de déchets dangereux. Cependant, on soupconne que cette quantité aurait considérablement augmentée au cours des dernières années.

Regardons en premier les définitions de "marchandise dangereuse" et de "déchet dangereux" afin de mieux comprendre leur inter-relation dans le cadre du Règlement TMD.

Une "marchandise dangereuse" est définie comme un produit, matière ou organisme qui, soit par sa nature et le risque qu'il comporte, est compris dans les classes figurant sur une des listes en annexe au Règlement TMD.

Un "déchet" est une substance ou produit pour lequel le propriétaire/ générateur n'a plus d'utilité, et le met au rebut.

Un "déchet dangereux" est un déchet qui, par sa nature et sa quantité, est potentiellement dangereux pour la santé humaine et/ou l'environnement, et qui requiert des techniques spéciales pour sa disposition ou la réduction du risque.

Les "déchets dangereux" incluent:

1) toutes les marchandises dangereuses lorsqu'elles sont inutilisables et tous les "types de déchets" des classes 2 à 9.3 figurant sur une liste en annexe du Règlement;

2) tous les déchets qui sont inutilisables et qui présentent l'un quelconque des risques déterminés par les critères de classification du Règlement.

Comme nous pouvons le constater, toutes les marchandises dangereuses incluses dans le cadre du Règlement TMD peuvent être considérées des déchets dangereux lorsqu'elles deviennent inutilisables. Sont cependant exclus du Règlement, dans le cas du transport autrement que par aéronef, les déchets dangereux en une quantité de moins de 5 kg ou 5L.

Le Règlement précise les exigences spécifiques concernant l'emballage des marchandises dangereuses et l'apposition d'indications de danger, telles qu'étiquettes, plaques et écritaux, sur tous les emballages des marchandises dangereuses ainsi que sur tout véhicule qui en contient ou en transporte.

L'application de ces exigences contribue à assurer la sécurité de la manutention et du transport des marchandises dangereuses. Les déchets dangereux doivent répondre aux mêmes exigences que les marchandises dangereuses.

Le Règlement présente deux particularités concernant spécifiquement les déchets dangereux. La première concerne la documentation. En vertu de la partie IV du Règlement, tous les envois de marchandises dangereuses doivent être accompagnés d'un document d'expédition. Lorsqu'il s'agit de déchets dangereux, ce document s'appelle un "manifeste". Le manifeste est un formulaire qui permet d'obtenir:

- des informations détaillées sur la nature et la quantité des déchets dangereux transportés;

- des informations de base sur les intervenants (expéditeur, transporteur et destinataire);

- des informations sur l'entreposage et l'élimination des déchets dangereux lorsqu'ils arrivent à leur destination finale approuvée.

Le manifeste comprend trois parties distinctes. La partie A est remplie par l'expéditeur, la partie B par le transporteur, et la partie C par le destinataire. L'expéditeur doit faire parvenir une copie de ce manifeste aux autorités provinciales responsables du lieu d'origine et du lieu de destination dans un délai de deux jours après la remise des déchets au transporteur. Les autres copies du manifeste sont acheminées par le transporteur et remises au destinataire lors de la livraison des déchets. Sur réception des déchets dangereux, le destinataire doit identifier toute différence entre la cargaison et la description du manifeste. Ensuite, il doit faire parvenir une copie du manifeste aux autorités provinciales responsables du lieu d'origine et du lieu de destination ainsi qu'à l'expéditeur et au transporteur, dans les deux jours qui suivent la réception des déchets dangereux. Une copie du manifeste doit être conservée par l'expéditeur, le transporteur et le destinataire durant les deux années qui suivent l'arrivée à destination des déchets dangereux.

Grâce à ce système il devient possible de suivre tous les mouvements des déchets dangereux "du berceau au tombeau". L'application uniforme de ce système à travers le Canada contribue à assurer la sécurité du transport des déchets de l'origine à la destination finale et à fournir des renseignements précieux en cas d'accidents.

La seconde particularité du Règlement concernant les déchets dangereux consiste en un système de pré-avis. Ce système a été établi pour donner suite à la Décision et à la Recommandation du Conseil de l'Organisation de Coopération et de Développement Economiques (OCDE) de février 1984 visant à ce que le pays d'origine ait la responsabilité d'assurer que le pays de destination d'un envoi proposé de déchets dangereux ait accès en temps opportun à des informations adéquates concernant le déplacement en question et ait l'option d'accepter ou de refuser cet envoi.

Selon le Règlement, les personnes désirant importer des déchets au Canada ou les exporter du Canada doivent fournir un avis écrit au moins soixante jours avant la date prévue pour l'exportation ou l'importation des déchets.

Cet avis écrit inclut:

- des informations de base sur les intervenants (expéditeur, transporteur et destinataire):
- des informations sur la nature et la quantité de déchets dangereux;
- le nombre d'envois prévus dans une même année de calendrier pour un même déchet;
- le port d'entrée ou de sortie au Canada ainsi que les provinces traversées;
- une déclaration attestant que des dispositions ont été prises pour la réception et le traitement des envois.

Donc, le Règlement TMD, de par son manifeste et son pré-avis, est en accord avec l'approche prônée par la Communauté Internationale en ce qui regarde le transport transfrontalier de déchets dangereux.

Au niveau de l'application de la Loi TMD, elle relève du Ministère des Transports. Le Ministère de l'Environnement a la responsabilité de faire l'application du Règlement aux points d'entrée et de sortie du Canada. Il a aussi la responsabilité de faire des recommandations et de fournir toutes les informations et les conseils techniques nécessaires au Ministère des Transports concernant les conséquences environnementales à court terme et à long terme de l'application du Règlement.

TRANSPORTATION OF DANGEROUS GOODS REGULATIONS

Canadian Truckers Association - Overview

Derek Wisdom, Canadian Truckers Association

Paper unavailable at time of printing

BIOMEDICAL WASTE HANDLING, TRANSPORTATION AND DISPOSAL

John Manuel, P.Eng.
Ontario Ministry of the Environment

With the recent introduction of the federal and Ontario regulations on the handling and transportation of dangerous or hazardous goods or materials, the attention of the human health care industry has been focused on the handling, transportation and disposal of biomedical waste. Generators now find themselves responsible, under the law, for the safe disposal of their wastes and, in fact, the actions of contract carriers that up to now may not have been properly licensed by the province to transport these wastes.

In 1982, the Ontario Ministry of the Environment had published its initial guidelines on the handling, transportation and disposal of pathological wastes and institutional waste and, at the same time, adopted the colour coding practice recommended in the Canadian Standard CSA Z317.10-M1981, "Handling of Waste Materials Within Health Care Facilities".

A public health emergency in 1984 arising out of the illegal storage of a large quantity of biomedical waste in the Town of Markham, Ontario, resulted in the provincial authorities setting up an inter-ministry task force to resolve the immediate threat to public health and to develop a long term management strategy for the disposal of these biomedical wastes. Various professional bodies such as the Ontario Hospital Association, the Association of Medical Laboratories of Ontario, the Society of Medical Officers of Health, the Municipal Engineers Association of Ontario and municipalities were invited to participate in the work of the task force. The terms of reference include the preparation of a disposal strategy that centres on the available incinerator installations currently in operation in hospitals and a study of alternative biomedical waste disposal techniques such as steam autoclaving and chemical sterilisation. As a result of the Markham emergency, the largest commercial diagnostic laboratories operating in the Toronto area were literally refused access to hospital incinerators and, as a stop gap measure, the province approved their use of large steam autoclaves for the purpose of steam sterilising their non-anatomical wastes prior to disposing in a landfill. With the recent accessibility of biomedical medical incinerators operating outside Ontario, these commercial laboratories have moved away from the use of their autoclaves.

As a result of the deliberations of the task force on biomedical waste, the Ministry of the Environment is expected to announce new 1985 guidelines for the handling and disposal of biomedical waste once agreement on the definition of the waste categories is accepted by the professional bodies involved.

The new Ontario guidelines on biomedical waste will reflect the federal and provincial concerns over packaging, handling and transportation of hazardous or dangerous waste as well as the manifest requirements under the regulations. Registration of waste generators, carriers and disposers is under way and should be completed before September, 1986. Hospitals, clinics, laboratories and other generators of biomedical waste now have essentially a one year grace period to decide whether on-site waste disposal is preferred over off-site disposal including taking the responsibility for the actions of a contract carrier and independent disposal facility. The last is attractive to health care institutions and laboratories. The alternative

methods of disposal now permitted, other than incineration, may result in new technology being developed for the safe disposal of certain categories of biomedical waste.

During the task force deliberations, the Ontario Ministry of Labour published new occupational health and safety guidelines on the operation, maintenance and repair of incinerators used to destroy infectious biomedical waste. The thrust of the guidelines is the avoidance of infection as a result of close contact with parts of such an incinerator that may harbour infection-causing substances. Similarly, the Ontario Ministry of Health published guidelines on the steam autoclaving of infectious materials and assisted in the preparation of a personnel accident/incident/injury/spill report form for the use of individuals handling biomedical waste in and outside any facility.

Finally, the Ontario Ministry of the Environment has revised the engineering design criteria for biomedical waste incinerators and new, technical guidelines will be issued. These guidelines will serve as the basis for any approval of future incinerator installations in Ontario.

To complete this review of activity in Ontario it is sufficient to note that while the planned biomedical waste management strategy may take several years to fully implement, there is no current concern over the existing procedures for waste disposal. Arrangements in place are adequate to deal with any perceived threat to the public health.

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Ontario Health Protection and Promotion Act, RSO 1980.

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A Guide for the Safe Preparation and Disposal of Antineoplastic Agents, Ontario Hospital Association, 1982.

Guidelines for the Handling of Recombinant DNA Molecules and Animal Viruses and Cells, Medical Research Council of Canada, 1980.

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HOUSEHOLD HAZARDOUS WASTE MANAGEMENT: LESSONS FOR CANADA

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INTRODUCTION

The management of household hazardous wastes (HHW) is receiving rapidly increasing attention throughout North America. Although volumes of HHW generated are low relative to industrial hazardous waste generation, the cumulative amount of HHW generated over a period of time by a community can be significant. Householders presently have no safe disposal options readily available to them. Instead, HHW is commonly disposed of with solid waste or down sanitary or storm sewers.

The disposal of HHW by these methods poses public and environmental health problems. These include:

- Injuries to refuse collectors and landfill, incinerator and sewage treatment plant workers.
- Landfill and sewage works equipment damage.
- Leachate migration from landfill/groundwater contamination
- Incinerator/resource recovery air quality concerns
- Septic tank/drainfield contamination or poisoning
- Disruption of sewage treatment processes/contamination of final effluent.
- Contamination of storm wastes

To counter unsafe disposal of HHW, new approaches to HHW management are being undertaken by a growing number of jurisdictions across North America. One successful approach, attracting widespread support, is the provision of collection and disposal programs specifically for HHW.

Although many different designs have been implemented to collect HHW, these fall into two overall systems: depot and door-to-door pick-up.

Depot Collection Systems

General Considerations. Collection of HHW using depot systems involves the provision of a depot where residents are asked to deposit their hazardous wastes. There are three factors to be considered in establishing HHW collections using depot systems: the geographic area served; the number of depots required to service this area; and the length of time per year each depot will be open. Table 1 lists the combinations of depot-based collection design that are possible according to these criteria. The implications of these design combinations are discussed below.

TABLE 1

Depot-Based Household Hazardous Waste Collections:

Possible Design Combinations

Area Served	Number of Depots	Days Open/year
1 city/municipality	1	1
		Several
	Several	1
		Several
Several cities/ municipalities	1	1 day
		Several
	Several	1 day
		Several

The combination of design criteria that is most appropriate for an HHW collection will depend on the specific conditions under which the collection is to be undertaken. For example, in a medium-sized city it may be possible to site a depot in a

location that is easily accessible to all residents on the same day. In contrast, a collection program in a large rural municipality may require several depots to be located strategically in the municipality in order to provide access to all residents. A third situation, perhaps in a Regional Municipality, may require that depots be located in area municipalities throughout the Region. In this case, the population base may make it desireable to operate at least some of the depots for several days, either in a block or periodically over an extended period of time, for example the first Saturday of each month over the summer.

Administration Administratively, HHW collection depots are relatively straightforward to operate and manage. A suitable depot location must be identified that provides both reasonable access for residents and sufficient space to separate the area where wastes are deposited from the area where they are classified and packed. If problems arise, for example from a spill, these problems can be contained on-site at the depot. Scheduling of waste drop-offs is not required since the depot operates for a continuous period of time on a particular day, or days. Regulatory concerns over siting a depot are likely to be minimized because of the fixed nature of the depot.

Handling Normally, a municipality or other lead agency running the program contracts out all tasks requiring waste handling to qualified, licenced operators.

The verification of labelled wastes, the segregation of these wastes into chemically compatible waste types and the packing of wastes for safe transportation are highly skilled tasks. In order to minimize public risk these tasks are usually performed away from the area where residents deposit their wastes. It is common for wastes to be placed in leak-proof containers and packed in either sand or vermiculite in 45 gallon drums for transportation.

Manpower requirements to service a depot have varied widely among HHW collection programs to date. Depots in small municipalities are reported to have been staffed by as few as two people. In Massachusetts, depot staffing levels have commonly been as low as three people in the more than 50 municipalities that have undertaken HHW collections since 1982.

On the other hand, other depot programs have used higher staffing levels. The Region of Waterloo program used 13 people in 1983 and 9 people were on-site at the Niagara-on-the-Lake depot in 1984. In these and other cases where high staffing levels have been employed HHW programs have been experimental in nature and high staffing levels have been used in anticipation of a heavy public response to the programs.

The issue of suitable staffing levels for depots is difficult to resolve since staffing levels must be decided in advance of a collection program and in anticipation of a certain level of public response. A higher response than anticipated can lead to understaffing depots relative to public response, as occurred in the Barnstaple, Massachusetts, program in 1983. Overstaffing can occur where response does not meet expectations.

In view of these uncertainties, initial HHW programs have tended to ensure that adequate staffing is available at the depots to handle a heavy public response, particularly in larger municipalities.

Costs The cost of running depot-based HHW collection programs has also varied widely to date. In part, this is because some collection programs have accepted small quantities of hazardous waste from sources other than residential households, for example small businesses and laboratories. The expanded scope of these programs leads to higher costs since more waste materials can be expected to be brought to the depots and higher manpower, transportation and disposal costs can therefore be anticipated.

Other factors have also led to significant cost variations between depot programs. Normally, depot staffing, packing and haulage are contracted out to a company qualified to undertake these tasks. A staffing cost of between $250 and $500 per person per day can be anticipated, depending on the functions and qualifications of the people involved. Thus, staffing costs are a very significant proportion of total program costs.

Important cost differentials also occur according to the billing structure agreed to with the handling/haulage contractor. Some contractors provide their services at a flat fee-rate; other prefer to incorporate a charge to reflect the quantity of waste material they handle. If a contractor over-estimates the quantity of materials to be handled and disposed of, a municipality may face a bill which it is contractually obligated to meet although the quantity of material handled did not justify projected costs.

Costs relating to the use of equipment have also varied among depot programs. It is common, for example, for the transportation vehicle that transports HHW away from the depot to be on-site during the time that the depot is open. However, the transportation vehicle is only actually required once the waste materials have been securely packed ready for transportation. Thus, transportation vehicles need not be on-site for the entire day.

Finally, publicity and public education can be significant cost factors. These are discussed in a seperate section below.

For these reasons, it is extremely difficult to make comparisons of costs for running HHW depot programs. Three examples, however, provide a sense of the range of costs incurred to date. In Lexington, Massachusetts, which may be considered typical of many programs in small and medium sized municipalities in that state, 4730 U.S. gallons of HHW were collected from 900 homes at a total cost of $4,200 during two one day collections in 1982/83. Two one-day depots in the Region of Waterloo cost $17,000 in 1983; 1150 gallons of HHW was collected from 200 households. In 1984, three depots in Sacramento, California, collected 9075 U.S. gallons of HHW from 900 homes at a cost of $25,000 exclusive of in-kind contributions from the private sector. Both the Waterloo and Sacramento programs were viewed as pilot programs and therefore incurred costs that could, perhaps, be avoided in future. However, these examples indicate that HHW program costs are highly site-specific and will depend to a large

degree on specific program design.

Door-to-Door Collection Systems

General Considerations. There are four basic systems that can be used for the door-to-door collection of HHW. These are given in Table 2.

TABLE 2

Door-To-Door Household Hazardous Waste Collections:

Possible Design Combinations

Type of Collection	Frequency of Collection (Days per year)
General Door-to-Door	One day
Targetted Door-to-Door	One day
General Door-to-Door	Several days
Targetted Door-to-Door	Several days

As with depot HHW collection designs, the choice of which door-to-door collection design is most appropriate for a program depends on the specific conditions under which the program is to operate. In some cases, it is possible to service an entire town or city with a door-to-door service on one day. In other cases, it is appropriate to offer a door-to-door pick-up service over several days. Targetted door-to-door collections have been offered in conjunction with a depot program; for example, senior citizens and disabled people can be eligible for door-to-door collection of HHW while others can be invited to bring their HHW to a depot.

Administration There are substantial administrative requirements for door-to-door collection of HHW. These stem from the need to minimize the risk of HHW spillage prior to collection. Unlike curbside collection recycling systems, with which door-to-door HHW collection systems are sometimes compared, HHW cannot simply be placed at the curb to await pick-up owing to the risk of the waste being knocked over, or otherwise spilled, or being ingested by animals or children.

In order to overcome this problem, and at the same time retain the convenience of a home collection service, door-to-door HHW collections have typically been preceded by a phone-in period during which residents are asked to contact the sponsoring agency and set a time when their HHW can be collected. The agency, or its contractor will then design a collection route according to

the location of households who have arranged an appointment to have their HHW collected.

Handling The handling of HHW in door-to-door collection systems is also complex. In order to minimize the time required to collect HHW, some door-to-door collections, such as in San Diego in 1984, have devised a two-stage collection design. In this type of design, staff travel ahead of the collection vehicle in order to identify and classify HHW before the collection vehicle arrives to pack and transport the waste away from the home. Other door-to-door collection systems have not incorporated the advance HHW identification feature.

Public Education and Publicity

Public education and publicity are vital to the success of HHW collections. Educational and publicity activities should involve a broad spectrum of community interests. This can be achieved by including a range of community groups in designing and promoting the HHW program. This approach ensures that a wide range of people will be aware not only that the HHW program is taking place, but also the importance of the issue. This understanding can be enhanced generally in the community through the distribution of educational materials to schools, presentations to community groups and service organizations and interviews with the local press. Municipal support for a public education program lends credibility to the HHW issues.

Commonly, educational material is given to individuals participating in the collection service when their waste is deposited, in a depot system, or picked-up, in a door-to-door system. Several jurisdictions have prepared educational packages related to HHW public awareness.

Costs for public education and publicity can be high, but can be defrayed by goodwill donations from businesses and other organizations in the community.

Program Profiles

The total number of HHW collections that have been undertaken in North America is unknown. However, there have certainly been several dozen collections and the rate of HHW collection program implementation is increasing rapidly. Most of these programs have been depot-based systems.

Two one-day depot-based HHW collection programs have been operated in Ontario, in the Region of Waterloo and at Niagara-on-the-Lake. Both are typical of many programs in North America.

The Niagara-on-the-Lake (population 12,500) program was held in the fall of 1984. A depot was located in a public works yard approximately 3 miles from the main urban area. Residents were invited to bring their HHW to the depot on a Saturday between 8:30 am and 4:30 pm. Prior to the collection day, flyers were distributed with the regular mail to ensure residents were informed of the HHW collection program. Residents who wanted to bring HHW to the depot were asked to complete, and bring to the

depot, a questionnaire included on the flyer concerning the type of waste they were bringing. This helped identify wastes at the depot. Local newspapers and radio stations carried stories on the up-coming HHW event.

The depot was staffed by 9 people, of whom 2 were volunteers with a local environmental group. The function of the volunteers was to assist in public education related to HHW by handing out flyers and answering any questions that residents had concerning HHW or hazardous wastes generally. Fifty-two households deposited HHW at the depot. Total costs involved are unknown since the waste handling and haulage companies involved provided substantial in-kind contributions.

A number of factors impacted on this HHW program. On the positive side, there was concern in the town over chemical contamination of drinking water and other issues relating to hazardous waste management. Also the collection day was timed to coincide with one of two annual oversize refuse collections. On the other hand, the Queen visited the town that day and a major town festival also took place. Both these latter events are thought to have impacted negatively on participation in the HHW collection.

The Niagara-on-the-Lake program is typical of many one-depot programs operating in one town for one day. Lexington, Massachusetts, is believed to be the first town in the U.S. to hold an HHW program, in 1982. Many features of the Niagara-on-the-Lake program, and other programs stem from the Lexington experience. The Lexington HHW collection, however, has become an on-going annual event, as have many depot-based programs in Massachusetts. The experience of these programs generally has been that participation in HHW collections has grown as residents become increasingly aware of HHW and efforts made to manage it. Commonly in Massachusetts, depot costs of under $5,000 have been incurred.

The HHW collection in the Region of Waterloo in 1983 also holds similarities to the Niagara-on-the-Lake program. However, the size of the municipality (population 315,000) necessitated two depots on successive Saturdays in the spring. The program was timed to coincide with an annual "clean-up" week in the municipality. The two depots were located to serve residents throughout the municipality; however, a survey of people using the depots suggested that the depots did not draw participation equally from throughout the municipality, but drew most heavily from residential areas nearest the depots. Combined costs of $17,000 were incurred for the two depots.

The HHW program in Barnstaple, Massachusetts, serves as a model for HHW collection in rural areas. This program was run over 3 days in seven counties, comprising all of Cape Cod. In contrast to the Niagara-on-the-Lake and Waterloo programs, the depots were located at sites of maximum convenience for residents, for example at supermarkets and schools. Depots were open successively for 2 or 3 hours; when one depot closed the staff and equipment moved to the next depot according to a pre-

arranged schedule. This milk-run approach was successful in stimulating participation from throughout a large, generally rural area. This program incurred costs of $14,000.

The most ambitious HHW collection program undertaken to date is the "Amnesty Days" program in Florida. This is a multi-million dollar state-sponsored program to collect not only HHW but small quantities of agricultural, industrial and laboratory hazardous waste. The intent is that every county in the state should be visited at least once by two mobile collection depots. By fall, 1984, over 100 tons of waste had been collected.

In contrast to depot systems relatively few door-to-door collection systems have been implemented in North America. Of those that have been, many have been complementary to depot systems.

The door-to-door collection in San Diego in 1984 is one of the better known HHW collections of its type. The service was provided to eight neighbourhoods in the city on eight successive Saturdays. Residents wishing to have their HHW collected were requested to phone the San Diego Environmental Health Coalition to set-up an appointment when their HHW could be collected. The Coalition worked with the City to implement the collection.

A comprehensive publicity and public education campaign preceded the collections. This campaign included both general major media strategies such as newspapers, T.V. and radio and targetted strategies, such as presentations to specific community organizations.

On average 25 households were served by the pick-up program over the eight hour collection period on each Saturday. Collection consisted of two vehicles and three staff. One vehicle, carrying a hazardous waste technician and a public education official from the coalition, identified the wastes to be collected. The second vehicle collected the wastes. The program report recommends that only one vehicle be used for door-to-door pick-ups in future as the two vehicle system proved inefficient.

The door-to-door pick-up program in San Diego was part of a larger HHW collection program that included the establishment of a depot to serve all parts of the city. The door-to-door collection served 201 households; however, 359 households requested collection and the balance of households, 157 homes or 44 percent of those requesting collection, failed to keep their collection appointment. The depot, which ran on only four consecutive Saturdays, was used by 88 households. Costs were not calculated for the door-to-door pick-up collection as a separate item from the entire collection and public education program. Total program costs of $77,000 were incurred.

Comprehensive socio-economic data were collected regarding response to both the door-to-door collection and depot collection in San Diego. Generally, a higher proportion of older people used the pick-up service than the depot. Also, a higher proportion of people receiving door-to-door service read the available public education material on HHW than did people using

the depot service. Of those who participated in the HHW collection program through either the pick-up or depot collections, 90 percent stated that the program had had some effect on their behaviour with respect to HHW.

The door-to-door collection service in the Marion County area of Kentucky was designed to serve rural generators of hazardous wastes. The specific objective of this collection was to recover banned or unwanted biocides, although other materials were also accepted. Residents of the county were requested, in the first instance, to bring their hazardous waste materials to a depot. Rural residents who were unable to do this because of inconvenience or other factors were served by the door-to-door collection program, which ran over a 5 day period. Approximately 55 pick-ups were made on a phone-in basis using a pick-up truck and one driver. Cost data are not available for the pick-up service.

CONCLUSIONS

Consumer products that can become hazardous wastes are in everyday use across North America, including Ontario. The recognition that HHW poses a threat to public and environmental health has stimulated the growth of efforts to provide residents with proper ways to dispose of HHW. To date, these efforts have focused on establishing temporary depots and to a lesser extent, organizing door-to-door collections to collect HHW.

There are advantages and disadvantages to both systems. Depot systems have been widely implemented. They require a relatively low level of administration, are easy to establish and have been refined to the point that tasks and costs are well understood. On the other hand, a depot tends to attract greatest participation from those who live closest to it and is therefore unable to adequately serve either a large urban population or a dispersed rural population.

Door-to-door collections hold the potential to provide large communities with a personalized HHW collection service. However, the impracticality of leaving HHW at the curb for collection has led to the need to schedule appointments with individuals who want to dispose of HHW. Experience indicates that this may, in fact, result in higher levels of inconvenience than are experienced by users of a depot. Thus, door-to-door collections have not necessarily resulted in higher praticipation levels than depot collections.

Costs for these two basic HHW collection systems are extremely difficult to compare for two reasons. First, a large number of depot collections, but very few door-to-door collections, have been implemented. Depot costs for pilot programs have often been high; however, many depots in the U.S. are now being implemented for under $5,000.

Many collections have included generators of small quantities of hazardous waste other than householders. Generally, this will result in increased costs and increased participation; in programs that have included hazardous waste

generators other than householders, the proportion of total participation attributable to households is generally unknown.

In spite of these uncertainties, successful programs have a number of common features. To date, the most successful HHW collections have been depot systems. Common features of these programs include:

- convenient depot locations
- high quality public education drawing attention to HHW issues
- assistance from a committed, qualified waste handler/hauler
- identifiable community environmental/public health issue related to hazardous waste
- municipal support

In addition, the implementation of a targetted door-to-door collection for specific groups of people who find it difficult to go to a depot, such as senior citizens and the disabled, is likely to increase the success of an HHW collection program.

Title: AN APPROACH TO ESTIMATING THE FATES AND QUANTITIES OF SPECIAL WASTE

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ABSTRACT

The Ontario Waste Management Corporation (OWMC) is in the process of designing and siting a special waste treatment facility. Although studies have been undertaken by OWMC and by many other jurisdictions to estimate special waste quantities, these studies have not allowed an explicit evaluation of how the quantities and types of waste received by various destinations will respond to changes in the regulatory and market environment. Studies in the past dealing with new facilities have generally assumed a portion of the market would be captured, but no explicit rationales for these assumptions have been reported. This paper describes a model developed for OWMC to estimate waste types and quantities sent for onsite and offsite treatment and disposal given specific technological, geographical, economic, legislative and social conditions. A primary feature of the model is its ability to deal with major shifts in the waste treatment market caused by new facilites and environmental regulations.

The model simulates the choices and decisions made by individual waste generators in managing their special wastes. A linear program formulation is constructed to choose the least cost solution.

Both onsite and offsite options are possible according to the waste type(s) produced. Over thirty onsite treatment technologies are characterized according to:

i) waste types accepted;
ii) residual types produced from the treatment;
iii) residual generation rates; and
iv) treatment costs.

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Onsite treatment costs are estimated for each possible technology according to the amount of waste to be treated; economies of scale result with large waste streams.

Sixty generic offsite destinations are specified according to:

i) geographic location;
ii) type of treatment/disposal technology; and
iii) disposal fees.

The generic types include:

i) transfer stations;
ii) private intermediate treaters (e.g. recyclers);
iii) private final treaters both in and out of province;
iv) specially regulated municipal landfills;
v) normal municipal landfills.

A final option relates to illegal disposal. The costs of this option are based on a submodel that estimates the expected cost of non-compliance given:

i) probability of detection of illegal disposal;
ii) the type of action taken by the enforcement agency (e.g. prosecution, control order);
iii) costs associated with each type of action.

Offsite transportation costs are estimated based on the distance from the generator to the receiver and the costing formulae corresponding to waste types and shipment mode (ie, bulk or drum) and size.

A representative sample of industries generating special wastes has been used to run the model. The results have been extrapolated to produce a total estimate of the flow of these wastes in the province.

The model is designed to accomodate significant factors likely to affect future waste quantities and fates (e.g. legislation and enforcement, disposal fees, economic growth, expansion of existing and building of new treatment/disposal facilities). The procedures to deal with each of these types of changes are discussed.

INTRODUCTION

In 1981, the Ontario government formed the Ontario Waste Management Corporation (OWMC) and set out as its objectives:

i) to research, develop, establish, operate and maintain facilities for the transmission, reception, collection, examination, storage, treatment and disposal of liquid industrial and hazardous wastes

ii) to initiate, stimulate, and encourage the recycling, reduction, recovery and exchange of liquid industrial and hazardous wastes by others.

This initiative was prompted by the concerns of government officials and the general public that many of these wastes, which OWMC calls "special waste", were receiving inadequate treatment and that existing private facilities were not able to deal effectively with them.

The problem of special waste is not restricted to Ontario and many government agencies in North America and Europe are grappling with this issue. Different approaches to building treatment facilities are being considered ranging from private operations to joint private/public ventures to sole public ownership. In all cases, however, a central concern is sizing and designing facilities to accomodate the quantities and types of wastes that will be received.

The matter of quantities and types of wastes is complex due to the wide range of factors influencing generation rates. For example, coincident with concerns relating to inadequate treatment of special waste, governments are introducing continually more stringent laws and regulations. These may restrict disposal locations, treatment methods, concentrations of contaminants in discharges, etc.; the result is that quantities and types of waste can vary significantly over the short term. The potential for variation may increase substantially when time horizons are extended to cover the investment period associated with major capital works such as special waste treatment facilities. Other significant controlling factors include i) economic conditions, ii) changes in production and waste treatment technologies, iii) changing consumer demand for products, iv) structure of waste treatment market (eg, prices, locations and capacities of other facilities, competitive strategies and flexibility, financial stability of waste generators and treaters), v) shifts in locations, types and size structure of waste generating industries.

As can be seen, the waste treatment market is highly dynamic which leads to significant uncertainty. This uncertainty is a primary consideration in designing a new facility. The question is how best to deal with this uncertainty in planning a new facility and eventually in marketing its services?

In the U.S., a number of states have conducted special waste inventories (eg, New Jersey, New York, Minnesota, California) and with the advent of generator waste registration, an extensive information base is being assembled in the U.S., and soon in Canada, on waste quantities and types. However, this information pertains only to current quantities and types and it will be a number of years before a sufficiently extensive time series of data is available to use trend analysis techniques to project future quantities.

To assess the need for additional capacity, a common practice has been to estimate current waste quantities generated and to project future quantities based on subjective modifiers. These are aggregate coefficients representing significant relationships. Exports and imports are subtracted and added to these totals. Finally, the existing capacity of private treatment facilities is subtracted. The residual quantities are assumed to be the shortfall in capacity. (For an example of this approach, see New Jersey Hazardous Waste Facilities Plan, 1985). These methods are somewhat more sophisticated than more ad hoc approaches. In these cases, typically total quantities are estimated based on generator surveys. Market proportions are arrived at through expert opinion and these proportions are applied against the estimated quantities to derive a facility waste quantity.

As part of its overall planning and development program, OWMC has conducted various surveys of waste generators and treaters similar to those undertaken in other jurisdictions. However, the Corporation wished to develop a more sophisticated approach for estimating the proportions of the waste quantities that they were likely to receive. The remainder of this paper describes the system developed and currently being used by OWMC to estimate the need for modern treatment facilities in Ontario.

SYSTEM REQUIREMENTS

The following section sets out the conditions under which the waste fates and quantities (WFQ) model approach was developed.

OWMC is aware that a myriad of factors affect waste flows in the province and has investigated what are felt to be the most significant variables. However, having completed many of these studies, the Corporation was faced with the daunting task of integrating them to observe their combined effects on waste types and quantities, particularly those which they could expect to receive.

The facility being planned involves a capital investment of more than $100 million with a twenty year operating life. Estimates of waste quantities and types are required for at least this period.

OWMC is committed to providing the highest quality of treatment and recognizes that different wastes require different types of treatment. It is therefore necessary that estimates of future quantities differentiate waste types according to treatment process requirements. This will ensure that the individual components of the facility are properly sized.

CONCEPTUAL BASIS OF ANALYSIS

This approach is based on a market concept of waste flows in the province and these flows are determined like any other segment of the economy. Waste generators are consumers of waste treatment services; this consumption represents the demand for these services. The capacity and prices charged by waste treaters define the supply of services. The flow of wastes is determined by the individual decisions made by waste generators as to which services they will use. Legislation and enforcement can affect both the demand for and the supply of services.

In order to represent this system it was necessary to define the available choices and the decision rules used to select a particular option. Figure 1 schematically represents the range of choices available to waste generators. They may partially or totally treat their wastes onsite or they may send them offsite to intermediate or final destinations. Intermediate treaters pass on wastes to final destinations.

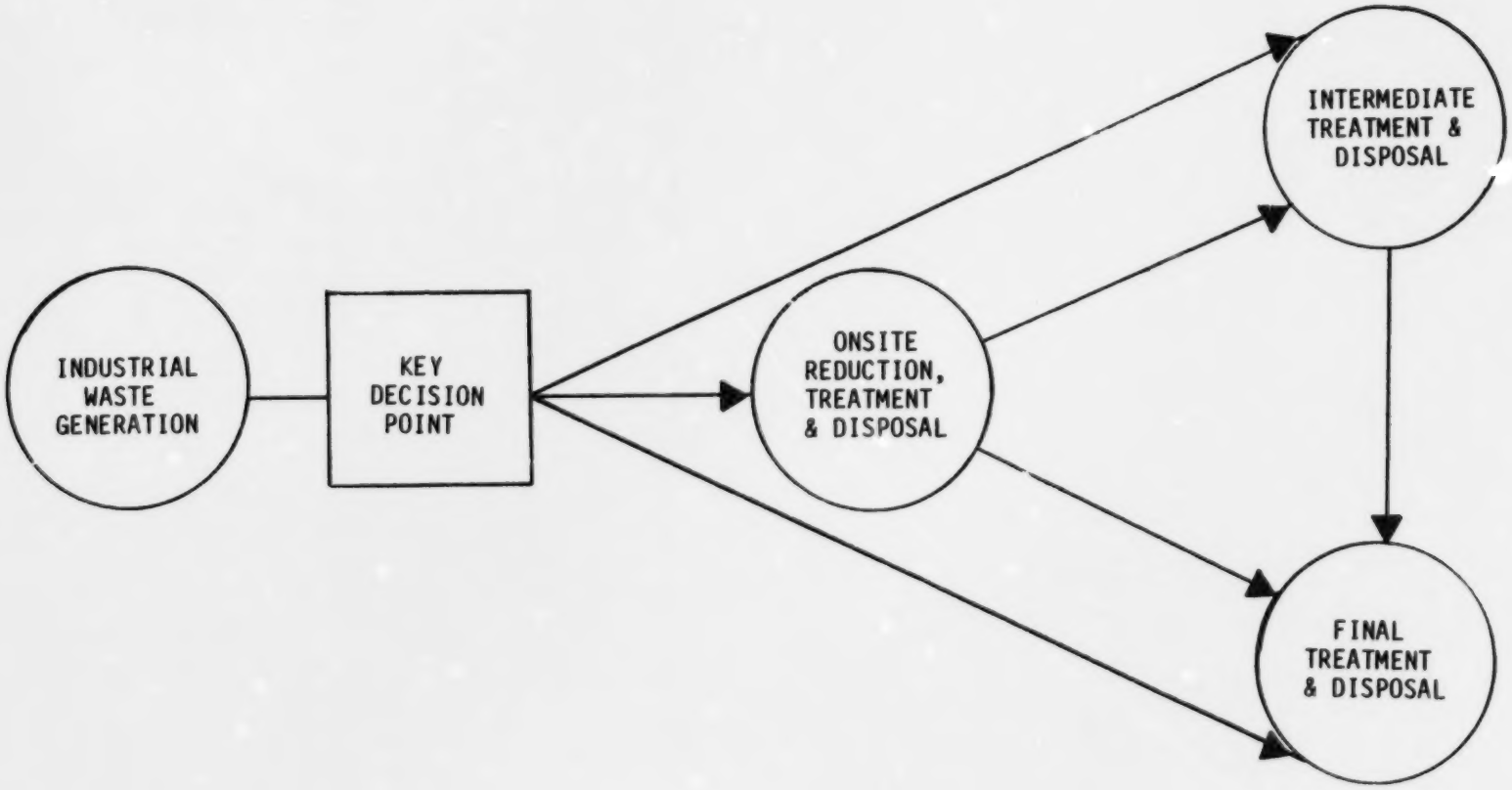
OWMC has studied how waste generators decide which waste treatment service they will use. It was concluded that cost is a primary determinant; accordingly, a least cost rule was used to simulate the decisions by individual firms. The option is available to adjust prices to reflect additional considerations such as liability and public image; this is done explicitly for illegal disposal as discussed later.

By analyzing the individual decisions made by a representative sample of firms, and then aggregating and prorating the corresponding waste quantities, waste flows in the entire system can be simulated.

It was necessary, however, to incorporate the various influencing factors into the analysis in order to judge their effect. The influence of these factors affect the system in one of four means.

FIGURE 1

ONTARIO'S INDUSTRIAL WASTE NETWORK



i) Economic growth and changes in product mix and production processes may effectively alter the waste generation rates (ie, the quantities and types of waste generated that need to be treated).

ii) Legislation, new facilities and new waste treatment technologies can change the range of onsite and offsite options available.

iii) New waste treatment technologies can also affect potentially treatable waste types and the characteristics and generation rates of residuals.

iv) Adjusted disposal fees, transport costs and enforcement of regulations may affect the total cost of offsite disposal.

By defining these relationships in quantitative terms, it is possible to incorporate them in the model and to directly test their effect on the results.

DETAILED DESCRIPTION OF WFQ MODEL

The implementation of this conceptual design required setting up for over 600 individual waste generators their decision environment (ie, the range of options and costs available to treat the specific types and quantities of wastes being generated); this task demanded computerizing the analysis. In addition, the least cost option could not be readily determined by inspection or a simple algorithm. This was due to the effects of sequential onsite treatment.

Three levels of onsite treatment are permitted. Onsite treatment may produce residuals which are suitable for further processing. All possible combinations needed to be considered.

The least cost onsite option is a function of the individual unit costs of each process (these are determined by the size of the waste streams to be treated), the efficiency and type of residuals produced and the offsite treatment costs (ie, disposal fee plus transport costs) of the initial and residual waste types. In order to determine the optimum level of onsite treatment, a linear programming (LP) formulation was set up.

The LP consists of a series of equality constraints to ensure mass balance within the system and inequality constraints to preclude infeasible combinations of treatment processes. The cost coefficients in the objective function are the unit costs of onsite and offsite treatment. The solution of the LP provides the optimum allocation of waste types and quantities among onsite and offsite options.

Following is an account of the individual files used in the WFQ model.

1. Industry Survey File

Survey records for over 600 manufacturing establishments that produce special waste have been compiled. There is one record for each waste stream produced by an establishment. The following data are used in the WFQ model:

i) SIC of the establishment
ii) geographic location of the establishment
iii) establishment size (ie, number of production employees)
iv) waste type (characterized by UCD classification system)

v) waste quantity
vi) physical state of waste (ie, liquid, solid, sludge)
vii) form (ie, bulk or drum)
viii) waybill code (ie, waybilled or not).

2. Extrapolation Factors

The sample of 600 firms represents a fraction of the provincial waste generation. The proportion of the population represented has been estimated for various strata. This analysis has led to an extrapolation procedure based on firm size and SIC. These factors are used to prorate the results of the model for individual firms.

3. Transportation Files

There are a number of files associated with transport costs. Two files provide the transport distance (kilometers) and time (minutes) between 45 locations. Of the 45, 34 correspond to aggregations of municipalities in the province, 3 are out-of-province centroids (ie, New York, Michigan and Quebec) and 8 are candidate OWMC sites. A third file lists the unit transport costs for various sizes and types of shipments. These files can be used to calculate transport costs from any of the 34 municipal locations to all of the other 44 locations.

4. Disposal Location and Fee Files

Sixty offsite destinations are represented in the model (table 1). To reduce the complexity of the analysis, transfer stations, intermediate treaters and out-of-province destinations are represented by centroids. The centroids are the weighted average (on the basis of waste quantities processed) location of these facilities.

The province was divided into six regions for these calculations (figure 2). A centroid was estimated for each regional destination and waste type combination and for the three out-of-province destinations. This produced a potential maximum total of 1185 centroids (ie, (6 transfer stations + 6 intermediate treaters + 3 out-of-province destinations) * 79 waste types).

The disposal fee file consists of the per tonne fee charged at the door for bulk and drum shipments of various types of wastes; a total of 79 different UCD waste types are included. (Note: The UCD waste classification system was developed in California and has been adopted by OWMC to categorize the diversity of wastes with which they are concerned.) These fees are derived from price schedules and estimated operating and capital costs of various facilities.

5. Onsite Treatment Technologies Files

Thirty on-site treatment technologies are considered. For each of these, the following is used:

i) treatable waste types
ii) residual waste types produced from each treatable type
iii) residual generation rate (tonne/tonne treated)
iv) treatment cost function ($/tonne).

TABLE 1

OFFSITE AND ONSITE TREATMENT AND DISPOSAL OPTIONS

REPRESENTED IN WFQ MODEL

Offsite

6 Transfer Station Centroids (1 per region)
6 Intermediate Treater Centroids (1 per region)
1 Tricil Mississauga Transfer Station
1 Tricil Sarnia
1 Polysar Sarnia
1 New York Centroid
1 Michigan Centroid
1 Quebec Centroid
5 Regulation 808 Landfills
- Guelph
- Paris
- Brantford
- Welland
- Hamilton TWp

34 Municipal Landfills (1 per municipal region)
1 OWMC
2 Illegal Disposal Options
- sewer
- non-sewer

Onsite/Offsite Technologies

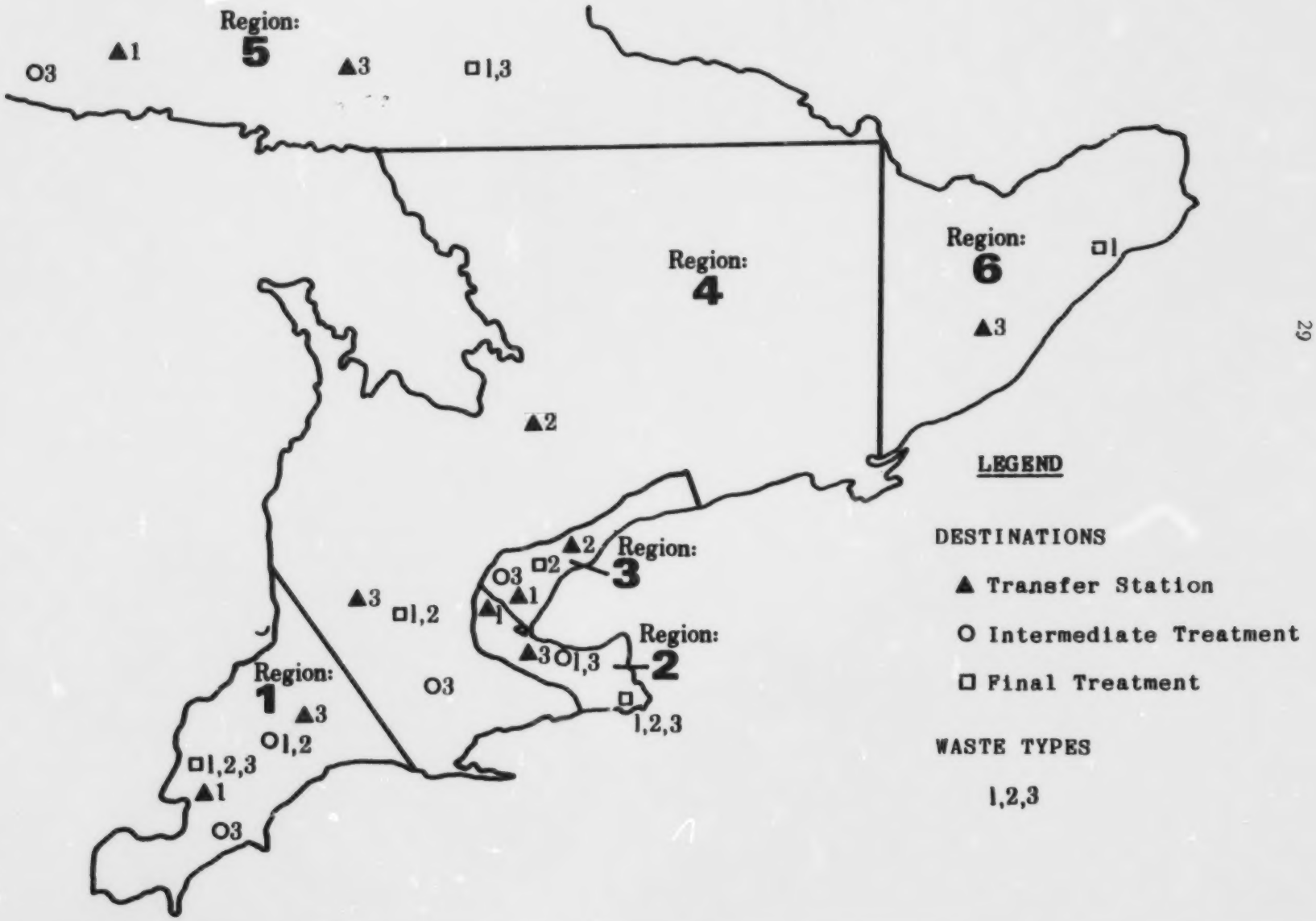
Coagulation/Filtration
Neutralization
Neutralization/Precipitation/Filtration
Precipitation/Filtration
Solvent Extraction
Oil Rerefining
- PROP
- acid clay
- distillation clay

Distillation
Oxidation
Wet Air Oxidation
Ion Exchange
Carbon Adsorption
Membrane Separation
PACT
Activated Sludge
Metal Recovery
Liquid Injection Incineration
- with scrubbers
- without scrubbers

Pyrolysis
Chromium Reduction
Oil Separation
Dissolved Air Flotation
Boiler Fuel
Sedimentation
Solidification
Evaporation
Filtration
Centrifugation
Sludge Farming

FIGURE 2

Regions Used by Waste Fates and Quantities Model and Hypothetical Illustration of Destination Centroids



Based on the types of wastes and treatment residuals, a set of suitable technologies is defined for each firm. A corresponding unit cost is calculated for the technologies based on the total quantity of treatable waste produced by a firm.

6. Regulatory Conditions Files

Projections have been made as to waste disposal legislative changes in Ontario. Their primary effect is to eliminate some offsite destinations at certain times in the future (eg, municipal landfills). In addition, they may result in surcharges and other increases in the costs of offsite waste disposal services. These changes are effected by either removing destinations as options for offsite disposal or by adjusting disposal and transport costs.

Another component of these files is what is termed the "costs of non-compliance". These costs are derived from an independent model that estimates the expected costs of illegal waste disposal. They are based on estimates of the probabilities of being detected and the types of action that may be invoked by the authorities. These probabilities are combined with the associated costs of the various actions to arrive at an overall expected cost. This cost is then increased by a factor to reflect indirect costs associated with illegal disposal (eg, public image, liability, social conscience).

In the WFQ model, illegal disposal is represented as an offsite option available to waste generators in the same way as legal destinations. The costs of illegal disposal, however, vary as the regulatory environment and public awareness change.

7. Economic Growth Files

Forecasts of economic growth based on the Informetrica Ltd. economic model are used to adjust future waste quantities. The forecasts cover a twenty year horizon and are according to industrial sectors (ie, 2 digit Canadian SIC). The cumulative growth factors are applied on an individual firm basis according to the forecast year and its SIC.

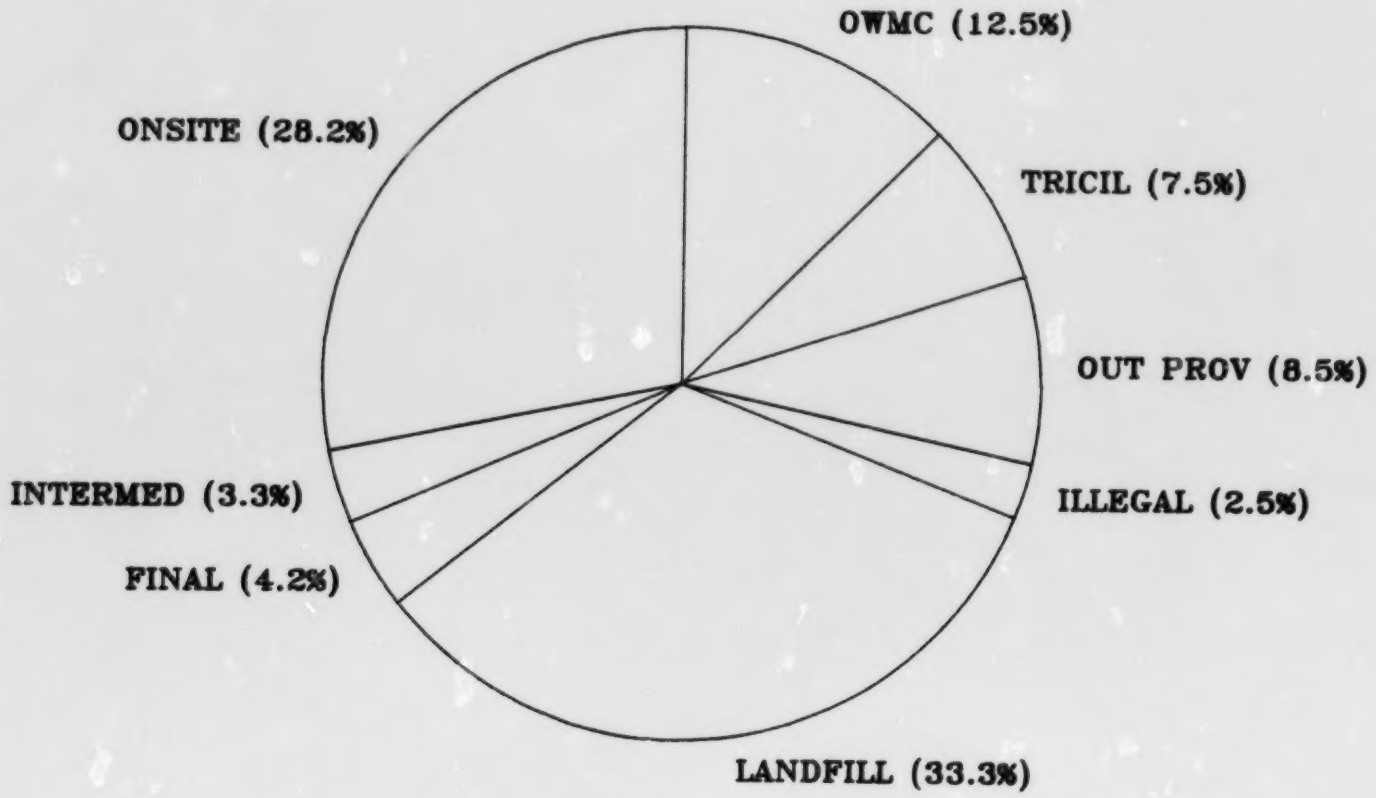
APPLICATION OF WFQ MODEL

Output from the model consists of estimates of waste quantities by waste type going to onsite and offsite options. This output can be simplified for easy comprehension to many forms (eg, figure 3).

The value of this type of analysis lies as much in understanding the sensitivity of the system as in the actual waste quantities estimates themselves. As a result, much attention has been given by OWMC to scenario synthesis whereby various configurations of the future are constructed and tested with the model. By comparing the output among these scenarios, one begins to focus on key aspects and this leads to the generation of new ideas on how to manage and influence waste flows. It also provides a basis for setting priorities for market research efforts. At the present time, OWMC is in the midst of scenario synthesis and is using the model as one means to estimate waste quantities it expects to receive.

FIGURE 3

HYPOTHETICAL WASTE DISTRIBUTION



The model has been designed in such away as to enable refinements in both its breadth and depth. For example, the model has been designed to enable technological change to be assessed. Attempts have been made by OWMC to investigate trends in product mix, production processes and new waste treatment technologies but no definitive results are yet available. The WFQ model is capable of handling such changes but the paucity of information on many aspects of waste generation and treatment is a major constraint.

As the Corporation enters the waste treatment market, the model will be able to incorporate new market intelligence gained through its operations and direct experience. The disaggregated and explicit structure of the model is a key feature in its ability to adapt as new information comes available. It is expected that it will be increasingly refined over time for corporate planning.

To summarize, we note some advantages and limitations of the approach.

1. The model provides highly disaggregated results that lend themselves to refinement and verification. Disaggregated information can be readily aggregated but not so the converse.

2. By adopting an explicit quantitative approach, the model forces consideration of the whole waste management system in an integrated sense. This has resulted in the realization of the importance of factors and relationships which might otherwise have been overlooked or discounted.

3. A disadvantage with this form of model, however, is the demands that it places on the user. The model attempts to incorporate the full spectrum of factors one would consider in arriving at an opinion as to likely waste flows. This demands that users describe their assumptions and opinions associated explicitly. The result can be a significant increase in the "discomfort index". It also reveals to all what is and is not known. Hopefully, this will lead to more informed and pointed discussion of the results and users with knowledge of only specific relationships can address these and rely on others for other additional information.

4. Unlike aggregate models derived from gross trends such as are used in other areas of economic analysis, this model is capable of dealing with new configurations of the waste management system and major market perturbations. These can be accommodated through definition of the specific changes that are expected to occur and the model then uses this specific information to estimate how the system in aggregate will respond. With aggregate models, one is left not only to speculate as to the specific changes but also how they are likely to influence coefficients of complex and difficult to comprehend compound variables that control the aggregate behaviour of the system. More often, specific changes can be anticipated rather than the overall response of the system to a variety of changes, particularly where virtually no historical record of the aggregate response is available.

L'ORGANISATION D'UN TRAVAIL DE

DECONTAMINATION A GRANDE ECHELLE

(RESUME/ABSTRACT)

Conférencier: Jean Paquin

Directeur technique Sanexen

Tout ouvrage de décontamination de grande envergure soulève des problèmes de logistique importants. Ces problèmes prennent une importance capitale si l'on désire effectuer les travaux de la façon la plus efficace et la plus économique possible, et cela sans sacrifier la rapidité d'action.

La conférence donne l'exemple des travaux entrepris à Varennes en novembre 1984 pour décontaminer des millions de pieds carrés de surface à la suite d'un incendie impliquant des BPC. Dans ce cas les infrastructures mises en place dès le début ont permis de rencontrer les objectifs mentionnés plus haut.

Toutes les suies, poussières et menus débris fortement contaminés furent aspirés et dirigés vers des équipements spécialisés situés à l'extérieur des bâtiments devant être nettoyés; ces équipements accumulaient les déchets concentrés et purifiaient l'air souillé. De la même façon un centre de décontamination érigé à l'extérieur a servi au traitement et au recyclage des eaux, des solvants, des équipements de protection et des déchets pour la durée des travaux.

Ce complexe de décontamination a permis l'utilisation de méthodes de nettoyage plus rapides et plus économiques tout en minimisant grandement le volume de déchets générés. Cette approche a de plus nécessité le développement de nouvelles techniques de traitement d'eau.

FACILITY SITING

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Efforts to site new hazardous waste management facilities both in the United States and Canada in recent years have proved to be both difficult and costly. State and Provincial legislatures have adopted complex and time consuming siting procedures. Extensive preapplication studies are required including the assessment of environmental, health and economic impacts, the evaluation of hydrogeological characteristics and the development of safety, emergency response and closure plans. For a typical waste management facility, this can cost a developer between $500,000 and $1,000,000 without any assurance that a permit will be issued.

Waste facility siting procedures usually call for public hearings on the proposed project and, in some instances, require the negotiation of a siting agreement between the developer and the community. The result is that the pre-permitting siting process is likely to take a minimum of one year and sometimes as long as two or three years. Too often, developers find that they are unable to absorb the upfront costs or they determine that the upfront risks exceed prudent business judgement and the developer voluntarily withdraws his application.

In analyzing siting attempts over the last five years in the United States, only a few projects have succeeded. In partial recognition of the problem, some legislative bodies have amended their siting statutes to provide for incentives for communities to host new facilities. The state of Tennessee will appropriate $1 million of unrestricted funds to any county that voluntarily becomes a host to a new waste management facility. In spite of this "carrot," no counties in Tennessee have accepted the offer.

The major reason for this is the public's perception of the adverse environmental and health risks associated with waste management facilities. Both in the United States and Canada, the career of an elected public official is short-lived if he or she should support the siting of a new waste management facility. The question is: can we design a siting process that both addresses the health and environmental concerns of citizens as well as provides a process that developers can live with?

One might hypothesize that there is a point where incentives offered by facility developers overcome community opposition to the project. The Lincoln Filene Center's Citizen Survey Program recently conducted a public opinion survey in five different communities in Massachusetts on the topic of hazardous waste

facility siting. The purpose of the survey was to determine the level of public opposition to a proposed facility and to test whether certain incentives might change people's minds about permitting the construction of the facility in their community. The surveyors examined 11 different proposals designed to provide either safeguards or financial incentives to the community. The following proposals are listed in their order of effectiveness in getting survey respondents to move from opposition to support of a proposed facility:

1. Guaranteed regular safety inspections by city or town residents or officials.
2. State and local public officials doing their absolute best to prevent groundwater contamination and accidental spills.
3. Provision of better fire protection for the whole city or town.
4. Provision of five college scholarships for local high school seniors.
5. Repaving the streets in the entire city or town.
6. Providing an insurance policy for every family in the community.
7. Hiring 15 local residents for the plant.
8. Paying property owners the amount of any decrease in property values.
9. Requiring the company to pay a surcharge on the amount that it processes.
10. Paying all of the city's or town's property taxes for 10 years.
11. Paying each resident $50.00 each year for 10 years.

The results show that public opposition to facilities may be diminished when developers offer greater safeguards in the operation of the facility to the community. Financial incentives seem to be less effective in diminishing public opposition. Interestingly enough, the surveyors found that there was less opposition to siting new facilities in urban areas than in rural areas.

The general conclusion of this survey is that it is essential to involve citizens early on in the planning process for siting new waste management facilities. Though viewed by the developer as time consuming and costly, citizen involvement begins to build an atmosphere of trust that is essential to reducing the typically adversarial climate in which new facilities are most frequently sited. Some states have adopted siting procedures that are sensitive to public concerns about hazardous waste management facilities. For a state siting process to be effective, it must provide the answers to the following questions:

- Is there really a need for this facility?
- Where will the waste come from?
- What are the potential effects on public health?
- What are the transportation routes to and from the facility?
- How many trucks trips will there be?
- What will be the impact of the facility on real estate values?
- Will the community have access to the facility and the operating and monitoring records?
- Can the community trust the government to adequately enforce state and federal regulations at this facility?
- What compensation will the community get for hosting this facility?

In analyzing siting both here and in the U.S., one can begin to identify certain generic steps that contribute to a climate of public acceptance for new facilities because these questions are answered. The first step is a needs assessment. This is an analysis of the amount of waste generated in the state compared to the amount of hazardous waste treatment capacity already existing in the state. The shortfall, if any, is an indicator of needed treatment capacity. Needs assessments are not easy to do. They are complicated by the fact that many generators are not anxious to publicize the fact that they generate large volumes of hazardous waste. Needs assessments are also complicated by the fact that the definition of hazardous waste can differ from place to place and, indeed, can change as new regulations are adopted. Last, it is difficult to factor in the influence of nearby regional treatment facilities that may reduce the need for new treatment capacity within a given state.

Opportunities do exist to involve the public in a needs assessment. First, a citizen's advisory committee can be formed to comment on the scope of the needs assessment. Second, and more important, the preliminary results of the needs assessment should be presented at public meetings throughout the state in order to get citizen response to critical policy questions raised by a needs assessment including:

- How valid is the database used for the needs assessment?
- Are the conclusions of the needs assessment generally credible?
- If new facilities are needed, should the state encourage the siting of large, integrated facilities or decentralized, specialized facilities?
- How can the state improve its siting process in order to respond to the need for new facilities?
- Should the state depend upon out-of-state facilities for future treatment capacity?

The next step is the identification of criteria that will be used to select new sites. Criteria should be developed both for areas that would be prohibited for the siting of future hazardous waste facilities as well as criteria that would be used to identify the most suitable areas for new facilities. Again, the public should have an opportunity to comment on these criteria through public meetings prior to their application. Examples of areas that might be prohibited for future siting include wetlands, areas adjacent to large centers of population, archeological sites, area of historical significance, farm land, areas adjacent to public water supplies, areas over major aquifers, public lands and land not zoned industrial.

The next step is site identification through the application of the site selection criteria. Using a map overlay process, areas can be screened out until a few sites remain that are considered to be a "above an acceptable environmental threshold" in that none of the prohibitive environmental, social and political criteria appear to apply to those sites. Once several sites are deemed to be above an acceptable, environmental threshold, it can be assumed that any one of them can be used to site a new waste management facility.

However, it is possible that one or more of the sites are better than the others. This should be determined by an environmental assessment of each site including soil borings to test for the presence of groundwater, soil permeability and distance to bedrock. Some state siting processes suggest that developers should form a citizen's advisory committee to provide community input on the selection of a site for the facility.

This is the process used so effectively to identify sites in Alberta and Ontario. As you know, the Alberta site is under construction and the Ontario site is undergoing final assessment. Although an area in British Columbia was identified for a new facility, that project is currently on hold.

The next step is to determine who the contractor should be to build the needed facility on the identified site or sites. Most state siting procedures encourage contractors to identify sites, conduct field assessments and make application for a permit to construct a new facility. However, some governments have initiated their own site screening process and then invited contractors to make proposals through a Request for Proposals (RFP). Citizens are frequently invited to recommend criteria for contractor selection and to sit on selection panels to identify the most qualified contractor to construct and operate each type of facility identified in the needs assessment.

Designing a workable siting process is not an easy task. Governments must decide whether to conduct their own site

screening process or to allow contractors to identify potential sites for new facilities. That issue is linked to the question of whether or not the government should issue a request for proposals for selecting potential contractors.

Perhaps the most difficult question to deal with is whether or not the government assumes the authority to override local zoning ordinances. Increasingly, municipalities are adopting local ordinances prohibiting the siting of hazardous waste management facilities and/or regulating the transportation of hazardous waste within their community. As a result, many siting processes now include the authority to override local ordinances that may result in prohibiting the siting of hazardous waste management facilities.

The evolution of workable siting procedures in the United States has been a gradual one since the passage of the federal Resource, Conservation Recovery Act of 1976 and the discovery of Love Canal, the Valley of the Drums and other widely publicized hazardous waste dumping grounds. It has only been in the last two or three years that siting procedures have begun to work. New facilities have been successfully licensed in the states of Ohio, Colorado, Illinois, Maryland, Rhode Island, Florida and in the Canadian provinces of Alberta and Quebec. Projects are moving through the licensing process in New Hampshire, Ohio and Pennsylvania.

In looking at the siting procedures both in the United States and Canada where progress is being made, there seems to be some basic elements that tend to enhance the successful siting of new facilities. Of major importance, is the opportunity for maximum involvement of the public during the siting process. Other common elements include:

- the development of a credible waste inventory or needs assessment justifying the need for the new waste management facility,
- a statewide public information and education program,
- a state managed site selection process with public participation in the establishment of criteria for site screening,
- state assistance grants to host communities to evaluate the proposed facility,
- state override of local zoning restrictions,
- a state managed contractor selection process with participation by the host community,
- a requirement for negotiated siting agreement between the contractor and the host community and the creation of a facility monitoring committee composed of host community residents.

The most recent attempt to site a waste management facility in the United States is in Pennsylvania by SolidTek Corporation. In this instance, SolidTek acquired a 635 acre site and conducted a series of hydrogeological studies to determine if the site met the state's siting criteria. Naturally, in this instance, it was not possible for the public to be involved in the site selection process. However, since the decision was made to go forward with an application to construct a waste management facility, public involvement has been intense.

SolidTek is proposing to build a fully integrated waste management facility including a laboratory, waste processing and recycling center and an advanced secure residue facility. Future phases of development will include a solvent reprocessing facility and a high temperature incinerator. When the project was announced to the public in mid-February 1985, SolidTek conducted a public briefing for local residents. Over 800 people attended the briefing, most of whom opposed the project. Soon after the announcement, the local residents formed CATS (Citizens Against Toxic Sites) to investigate both the proposed project and SolidTek Corporation in an effort to encourage the state to deny the issuance of a permit.

Since then, SolidTek has put together a slide presentation which has been shown to virtually every civic organization in the area. They have invited local public officials to appoint members to a citizen's advisory committee whose function it will be to review various elements of the project application in order to assure that the needs are the concerns of the community and are reflected in the project application. SolidTek has also asked the citizens' advisory committee to propose ways in which potentially adverse impacts on the community might be mitigated. SolidTek has opened an office in the host community where citizens can come to obtain information about the proposed project. The company is also publishing a monthly newsletter which is circulated to approximately 700 area residents keeping them informed about the proposed project and about the status of the project application.

The company has arranged for regular tours of the proposed site and will be asking area residents to visit their similar facilities. To mitigate transportation impacts, the company is considering putting an abandoned rail line back into service. The company is also developing a plan to provide some sort of guarantee or support for housing values of abutters to the proposed site. If the permit application is approved, the company will encourage the citizens' advisory committee to continue to provide oversite on the operations of the facility.

SolidTek estimates that it will take one year to complete the permitting process in the state of Pennsylvania. They

estimate that they will spend approximately $1 million during this period. Despite the history of siting failures in the United States, the company is encouraged by the prospects of the permit being issued. They feel that there are six basic reasons why their chances of success are enhanced:

- The unblemished record of the company in operating other facilities.
- The state-of-the-art technology proposed for this facility.
- The high level of public involvement in the siting process.
- A demonstrated need for the facility.
- The willingness of SolidTek to bare the upfront costs.
- The site is hydrogeologically sound.

In conclusion, there are some who assert that public opposition to the siting of waste management facilities is so strong that new facilities would never be sited. On the other hand, we do have some recent examples of new facilities that have been successfully sited in the United States. It appears that some states' siting procedures have been able to achieve a balance between the involvement of the public and the potential risk to project developers. Hazardous waste needs a safe place to go and the public is beginning to realize that the safest place is a new, modern waste treatment facility, even if it is in their backyard.

PUBLIC RESPONSE TO ENVIRONMENTAL CRISES

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T.A.G. Watson, Tricil Limited

INTRODUCTION

Crisis, or disaster management is a topic gaining increasing prominence in general management circles.

Some six years after Three Mile Island, society experienced Bhopal and its aftershocks in North America. Closer to home, this spring we had a series of PCB related incidents, the public's awareness of which reached national prominence with the Kenora TransCanada Highway Spill.

Those of us in the environmental communication side of industry have watched with some degree of frustration as a seemingly endless series of incidents reached an unprepared public, strengthening an already measurable concern about chemicals in the natural environment.

It is our contention that while ways and means are available to clean up and to protect the natural environment, the communication component of crisis management needs to be far better developed, if the general public is expected to agree with and therefore allow necessary programs to proceed.

While we may be able to physically manage environmental crises, have we paid enough attention to our responsibility to communicate our progress or lack of it during the crisis period?

By way of background and introduction let us define a crisis and examine the inter-relationship of players in the piece.

CRISIS DEFINITION

An environmental crisis or any crisis for that matter should have the following five components:

1. Trigger
   An action or event which results in events moving beyond a norm.
2. Urgency
   The event requires immediate action to gain control.
3. Uncontrolled
   The event must be beyond the control of any organization for some period of time.
4. Threatening
   The event poses negative implications for any or all the following:
   - people
   - property
   - the organization responsible.

5. Requires Action

An organization must initiate action to resolve the consequences of the event.

Also, crises in public confidence can occur as opinion turns against an institution or organization.

THE PLAYERS

. The broad "general public"; the voting constituency - caught in a crossfire of competing messages.

. The media; sensitive to special interests - needs events for news content.

. Government; must monitor, enforce, develop new legislation - subject to political necessity.

. Special interest groups; watchdogs over industrial/ government complex - highly thought of by public.

. Industry; inward-looking, plant-oriented, thinks cause-effect-fix, problem solved.

Each has its own perspective of the seriousness of the event; all the players get an amalgam of all views through the popular media.

This inter-relationship can be portrayed as:

PLAYERS' RELATIONSHIPS

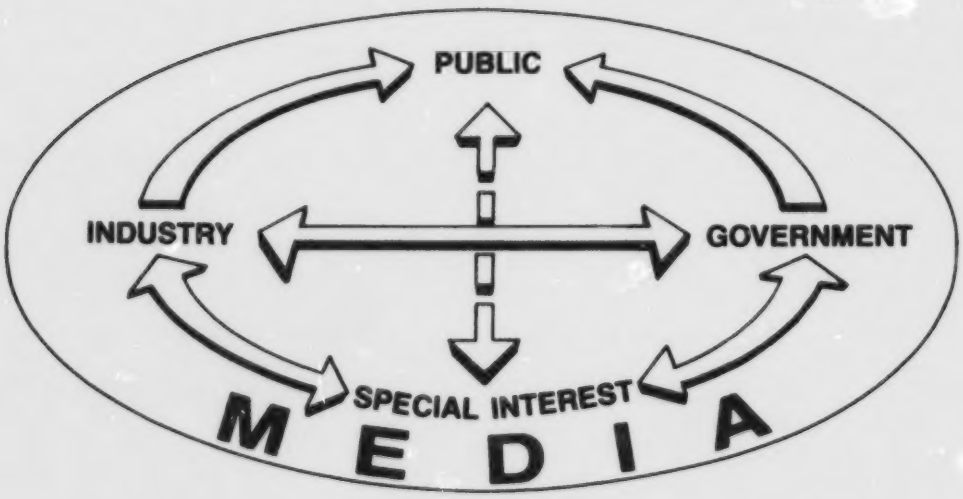


FIG. 1.

Each group except for the public has its own direct interaction with other groups; the media acts as an amplifier of these relationships for the public consumer.

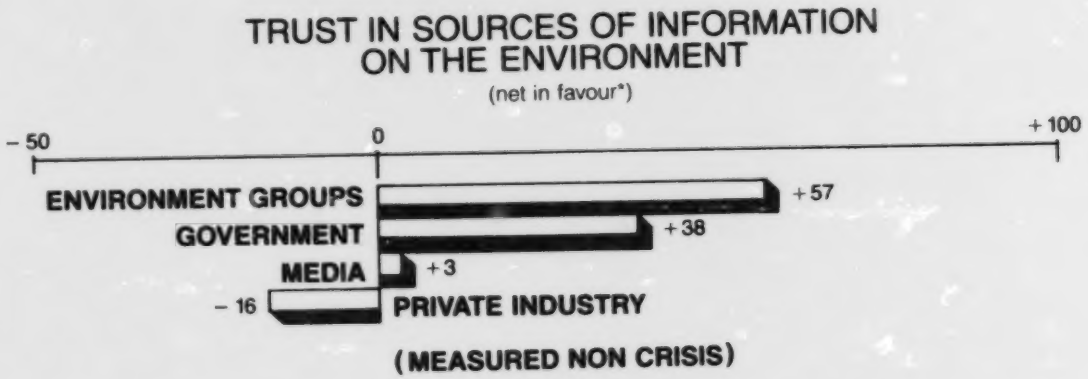
If society is to be successful in cleaning up and protecting the natural environment then all players must have a general understanding of the objectives and the means of reaching them.

To promote such understanding, ideally we require:

- a comprehensive set of facts -- information
- an agreement on the degree of environmental improvement required
- willingness among the players to trust and work with one another -- good faith.

In reality, we have by degrees, deficiencies in all three requirements.

We know how much trust the public puts in environmental information from four sources:



* Net in favour of high trust; High = 8-10 on ten point scale, minus Low, 1-3 on same scale.

ref. Canadian Facts, Study LE 195/GH, 1984

FIG. 2.

In times of crisis the public is inundated by conflicting reports of the degree of seriousness or danger inherent in the situation. The volume of the discussion is turned up to such levels that distortion of the message often occurs in channels already overloaded with information.

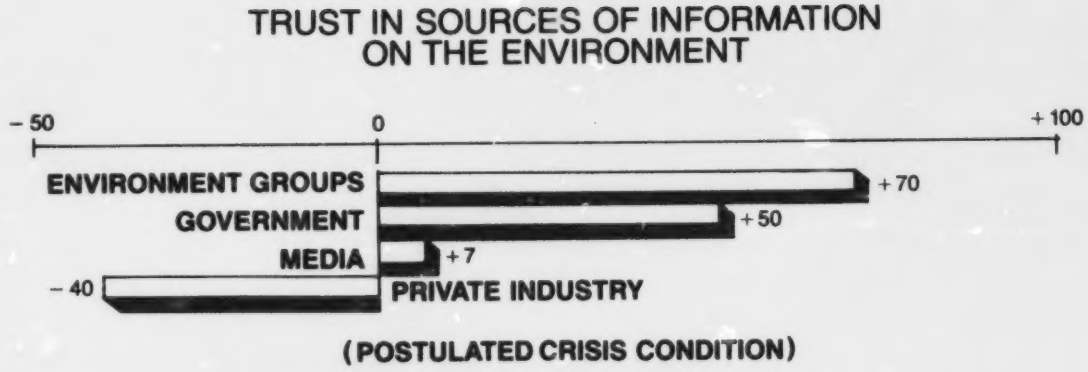


FIG. 3.

As a crisis subsides, it is reasonable to assume that the net gainers in the event, for a time, are likely to be the interest groups which have the "public good at heart", and the media, which told everyone the "facts". The net losers will be the industry which precipitated the event because "profits come ahead of the environment" and the government, which "doesn't do enough to protect the public".

SOURCE RELIANCE

A study by the Media Institute in Washington, published in March of this year, analyzed the content of media coverage of the Livingston Louisiana train wreck in 1982, the ethylene dibromide scare and the Times Beach incident of 1983.

In analyzing coverage from the New York Times, the Washington Post, the Los Angeles Times and television coverage from the three major U.S. networks, the researchers found among other things that:

. "Government spokesmen were used disproportionately as sources -- more than all other sources combined...half of all statements by government sources (53.1%) asserted the need for action."
. Public interest groups devoted 60.7% of their statements to charges that risks were great enough to warrant action, while the "man-in-the-street" - the public, scored 58.6% on the same basis.
. "Outside experts and industry sources were ignored, or quoted sparingly at best."
. "Scientific data were used sparingly... ranging from a high of one quarter of the coverage to a low of 0."

Our view as industry players is that doing the job of controlling a crisis -- actually cleaning up a spill or recalling product -- is not good enough. Sending accurate messages about what the job actually is and how it is being done is equally important if the reality of a situation is to be portrayed and players' credibility enhanced. These requirements are just as valid for governments in their regulatory roles during crises, and for environmental groups acting as watchdogs.

To find ways of sensitizing industry operations people to the information needs of the public, regulators, media and special interest groups, an exercise was undertaken early this year.

It involved reaching consensus by two groups, each of which has a necessarily different role during a crisis and hence has a different view of the impact of a single set of circumstances.

Broadly, we wanted to find a way for crisis managers to better understand the communication content and thus the perceived consequences of their behaviour in crisis situations.

SENSITIZATION PROCESS: UNDERSTANDING CRITICAL SPACE

Now, we've said all that so we can explain this: a process we believe will help significantly in understanding the perceptual flow of a crisis as it unfolds. The importance of understanding the flow, is that one can determine what corrective communication actions should have been taken during a crisis in order to more quickly respond to emerging external fear, misconception and hostility.

For while the system we will describe works well in reviewing and placing into context the perceptual flow after a crisis, it would appear that it may also be used as a progressive monitoring device during a crisis if a sensitive, open approach is applied.

By plotting perceptions, one will be able to see how two views of reality can deviate and therefore create a chasm -- what we call "Critical Space". Critical Space is the gap that is allowed to develop between levels of perception, and in this area can and will emerge perceptual conflict which in turn leads to real conflict. This Critical Space, in the following case, separates that which operational people see as the reality of a crisis, as against that which external audiences believe is happening.

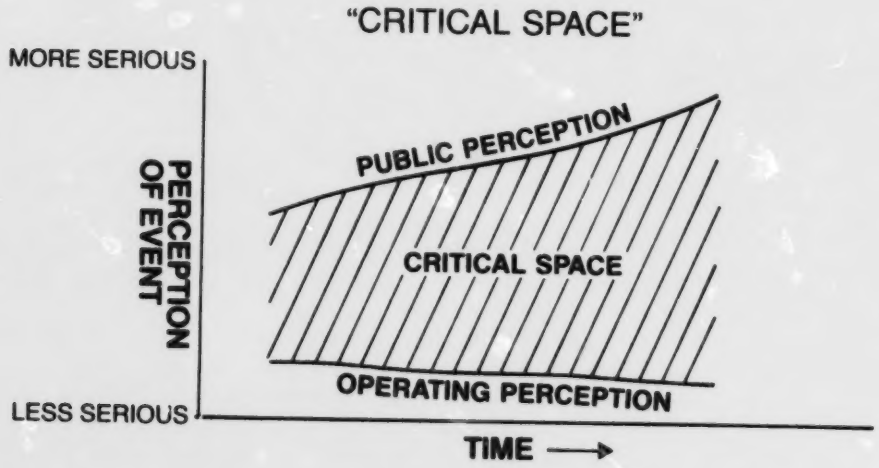


FIG. 4.

The first step in examining this process took place in late May, 1985, during a four-day "retreat" to build a generic crisis communications program. Invited were five communications professionals and three operationally-focused resource people, all contributing information gained from their on-site experiences during crisis situations, such as major plant explosions, toxic chemical spills, fugitive emissions, aircraft crashes, and strikes.

During the course of our discussions, Russ Hall, a mechanical engineer who has been with C-I-L Inc. some thirty years in numerous chemical manufacturing managerial positions, raised a great question. He wanted to know how to measure the severity of a crisis. That question led to the creation of what we have come to call the Hall Window.

HALL WINDOW

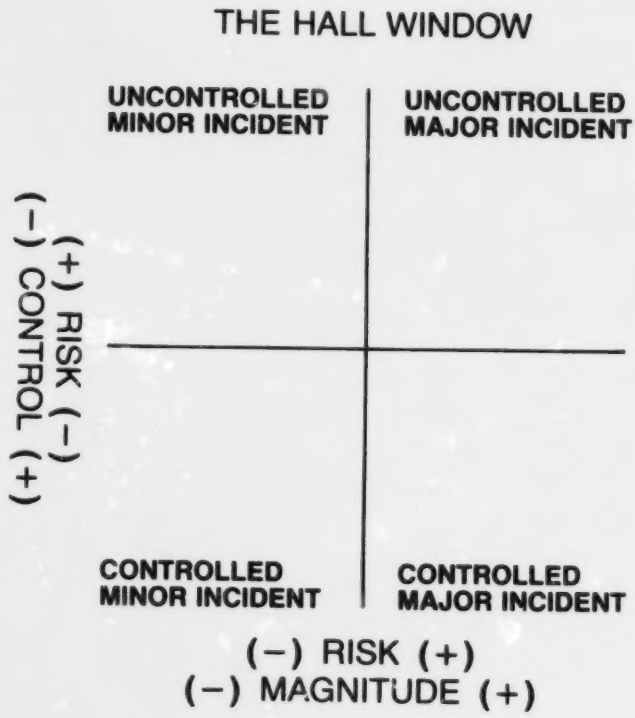


FIG. 5.

The Hall Window uses an ordinal level of measurement to describe a crisis. The lower left quadrant belongs to incidents which are controlled and minor; the upper left quardrant is for uncontrolled minor incidents. Moving to the right, the lower right quadrant is an area where increased magnitude and risk of an incident makes it still controlled, but now major in scope. And the final quadrant, at the upper right, is for an uncontrolled, major incident.

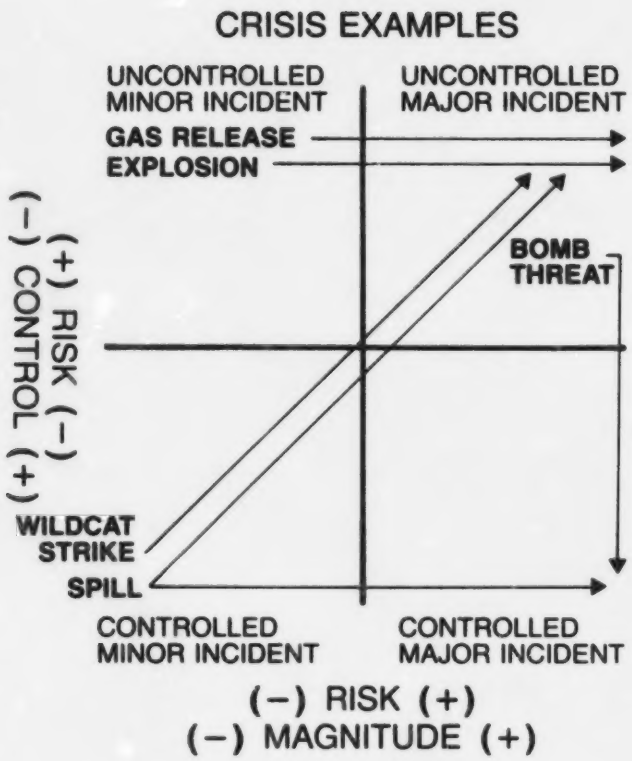


FIG. 6

For example, if we overlay some situations on the Hall Window, we can see that a wildcat strike can start as a controlled, minor incident and blossom into a major, uncontrolled event. An on-site spill can be a minor controlled incident that expands into a major controlled incident, or, if too many things go wrong, into a major uncontrolled incident. Conversely, an explosion can start off as an uncontrolled minor incident, but has the potential to escalate into a major and uncontrolled incident...as does an inadvertent gaseous release. However, a bomb threat must begin as an uncontrolled major incident, stay there if real, or quickly move into the controlled quadrant.

In other words, the Hall Window allows us to look at any incident and chart its scope, thus yielding a description of its severity. If objectively done, a quick picture of the current and potential extent of an incident emerges.

By adding two elements -- time and how an incident is perceived on two levels (operational and public) -- we are able to build a system of tracking a crisis. It captures two levels of reality as they emerged.

To appreciate the process, we must first agree on four statements:

1. that operational staff in a crisis is justifiably pre-occupied with bringing the crisis under control;
2. that operational people work from a position of knowledge and expertise, and thus, even in a difficult crisis will perceive less danger from the event than external audiences;
3. that, conversely, external audiences will perceive more danger and threat from that same crisis because of their own lack of knowledge, and their sense of imminent danger;
4. that all things being equal, those external audiences will be more critical of any emergency action because they will assume the crisis should have been avoided and that they are not privy to all the information, which therefore means the crisis is likely more dangerous than they are being told.

When placed into a common equation, the four statements invariably lead to conflict in peception of reality. While operational people are busily working to contain and neutralize a crisis, external audiences, when not properly, fully and constantly informed, will develop their own views -- more often than not in conflict with actual events.

To track these conflicting perceptions of reality, and track the Critical Space that defines the separation of conflicting realities, we have expanded the Hall Window.

APPLYING CRITICAL SPACE

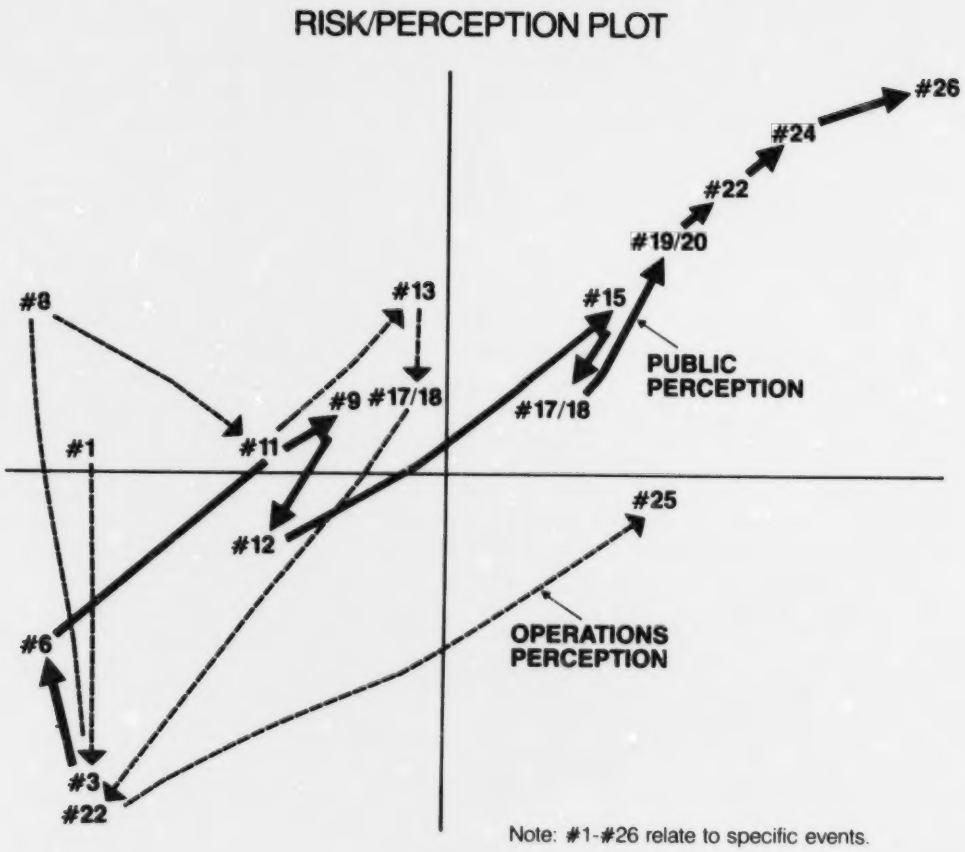


FIG. 7.

Specifically, we used the Hall Window to capture an actual incident -- in this case, an explosion in a chemical plant during which product escaped from the plant property as a strong odorous gas. This event was followed by a contained on-site spill within a few days.

By using the Hall Window as a risk/perception plot, we were able to track both operating management's and the public's views of the risk of same situation. This is represented by the two lines in Figure 7.

In order to build a meaningful risk/perception plot, it was vital that both operating management and public perceptions be registered realistically. That meant no point would be placed on the graph without a consensus as to its degree of risk being reached by both sides.

In our development process at the retreat, operating management's view was represented by the operationally-focused resource people based on first-hand experience; the public's view was represented by two of the communications professionals who were involved in monitoring the incident.

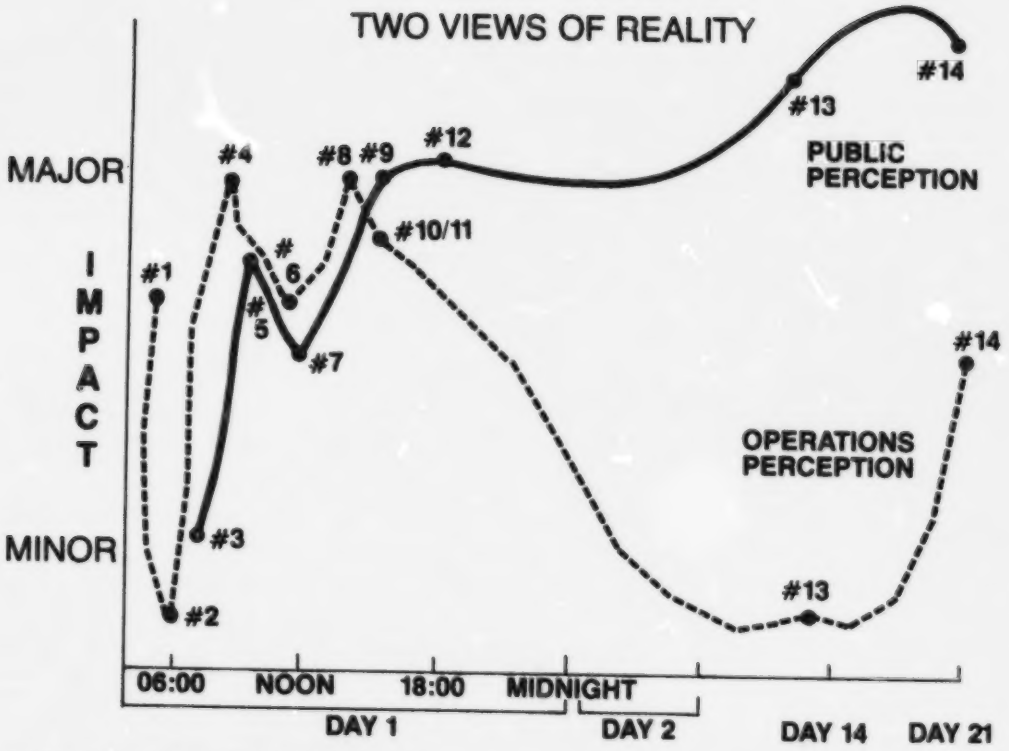
It took more than half a day to debate and agree on the perceived degree of risk step of the incident. Through this intensive give-and-take process, each group developed a much broader and more enlightened understanding of the other's real options and constraints which apply during a crisis.

It is the recognition and management of these options and constraints which directly leads to the size of the Critical Space bounded by two sets of perceptions.

At the end of the session, Figure 7 emerged. Standing alone, however, it did not yield an easily-interpreted picture.

As a result, we added a time dimension along the Y axis and used the risk/perception values as an impact scale on the X axis.

We then had an "event" dimension, and a "time" dimension. Together, they allowed us to plot a crisis and provide a progressive snapshot of the two realities.



HIGHLIGHTS OF THE INCIDENT

1) Chemical drums explode at a company site.

2) The situation is assessed by plant personnel and company supervisory personnel. The appropriate authorities are notified.

3) The incident as first reported by the media, is described as a minor event that has no consequences beyond the plant site.

4) Community authorities notify plant management that they have received reports of odors and believe that the explosion has resulted in a vapor cloud extending over portions of the community.

5) The reports are discovered by the media and attention of the incident escalates.

6) Company health officials contact local health authorities to advise them of the nature of the vapor cloud and its possible effects on human health and safety.

7) The company calls a news conference to issue a statement on the facts surrounding the event and to answer media questions.

8) During the course of questions and answers at the news conference, a member of the media cites undisclosed scientific studies which identify the vapor as both carcinogenic and mutagenic. Company spokesman are not familiar with data cited; they are unable to dispute claims.

9) The news conference ends with the situation unresolved.

10) Members of the media contact neighbours of the plant to get their reaction to the incident.

11) Company officials give company side of story to some, but not all, employees.

12) Increased community and official concern is expressed regarding the effects of the vapor.

13) Another incident occurs at the plant site – this time a chemical spill.

14) Official charges pressed.

FIG. 8.

As can be seen, initially operating management's view and that of the public are closely parallel. However, operational staff, understanding the incident and the chemical in question, rapidly perceived the crisis to be over; that from a fairly major event, it quickly deflated into a minor incident.

The key point is that external audiences did not share that comfort level. In fact, their own sense of concern continued to rise, reinforced by a second incident.

Clearly, the absence of information compounded by the presence of continuing concern created a wide Critical Space. That gap is precisely what leads to public confusion, diminishing operational credibility, and increasing external hostility.

THE LESSON OF CRITICAL SPACE

Looking at the issue globally, the size of any Critical Space is not necessarily an indictment of operating management's insensitivity. Responsible operating management will do what is required to effectively manage the physical manifestations of a crisis, as they have been trained to do. That their level of practical knowledge relating to communications may not be as developed as is now desirable is more a symptom of a management style no longer able to satisfy public expectations.

The public also is reacting predicably, having been further sensitized in this post-Bhopal era to believe their fears.

If we are to reach an understanding of the degree to which we all must protect the environment, then there are obviously some steps that need be taken to develop mutual trust among all the players involved in a sustained dialogue, and particularly in periods of crisis.

One key step is to raise the awareness of those in control of crises so they will appreciate the need for clear communication with the public.

Another key step is to begin a long-term process of public education as to what is really known about the effects of a given environmental crisis.

If we are successful, it will be because we will have reduced the size and shape of Critical Space. The objective, clearly, is to bring the upper and lower bounds of the Critical Space into a parallel and intimate alignment.

Media and special interest groups have a responsibility to all players to report any incident or potential incident. However, that responsibility should carry with it an accountability to integrity; in other words, they must raise and deliver issues objectively and factually, avoiding sensationalism where none belongs.

Government's role should be to remain as the ultimate safety net. That implies not only having the right to take protective action, but the need to build its own credibility as a reliable, trusted source of information on the protection of the environment ... an area occupied to a disproportionate degree by environmental action groups.

Above all, it is important to bear in mind that the public has perceptions and resultant images of industry, government and special interest groups. And because it does, the public will consistently discount information from the former two while attaching greater credibility to the latter. It is a perceptual reality that underscores the very point of this paper: that gaps exist between what we think we are saying and doing, and how those watching us interpret our words and deeds.

Industry is learning its emerging communication responsibilities, and government, for its own interest, must also try to capture more of the high ground of credibility more quickly. Together, these players must work effectively with responsible special interest groups and media to help all of us cope with crisis when it occurs...and move forward to new levels of mutual trust and understanding that ultimately benefits everyone.

That option does not preclude each player's prime responsibility ; rather, it recognizes that each player needs to be more consistent and careful in advancing public understanding if workable policy is to emerge and prevail.

PERMITTING OF THE EXTENSION TO THE TRICIL (SARNIA) LTD. INDUSTRIAL WASTE LANDFILL

(RESUME/ABSTRACT)

By: Eric Hunter (Speaker)
Alan Cadotte

In the summer of 1983, Tricil commissioned a detailed hydrogeologic investigation of the property it owns adjacent to its current industrial waste landfill site. Several state-of-the-art sampling and analytical techniques were applied to characterize the site, which was found to be one of the most suitable that could be found for the entombment of wastes.

Based on the site data, a comprehensive assessment of the potential environmental impacts was undertaken, including a series of sophisticated computer modelling methods to evaluate the diffusion of organic and inorganic contaminants through the soil.

A landfill design and operating plan was developed, which included a new solidification facility to pretreat non-solid wastes before landfilling.

The formal application was submitted to the Ministry of the Environment of Ontario in early 1985 and an Application was made to the local municipality for rezoning the property and for an amendment to the official plan.

To ensure a clear understanding of the proposal and the regulatory process, a communications program was initiated in the fall of 1984. A newsletter called "Common Ground" was started and the distribution included 1500 residences in the neighbourhood of the facility and others throughout the province. A number of summaries of the Application were prepared of various lengths to present the technical information in a readable fashion. Public meetings were held to describe the proposal and, subsequently, reports were prepared to address the concerns raised by the neighbours and others throughout the province.

This paper presents a summary of the Application and the current status, including the results of the public hearings.

UNE FAÇON DE FAIRE

Jean Godin
COGESULT INC.

1. INTRODUCTION

Bertrand Russel déclarait il y a déjà quelques temps que, dans un monde de plus en plus unifié sur le plan technologique, l'existence dans une tour d'ivoire devient de moins en moins possible. (1)

Aurait-il voulu évoquer l'implantation d'infrastructures ou de projets industriels qui, pour réussir, imposent à la société moderne l'interaction et l'intégration des corps politique, socio-économique et scientifique, il n'aurait pas mieux choisi ses mots, à mon avis.

Travailler de concert avec les différents publics lors d'une implantation de projets qui touchent la gestion des déchets est un exercice long, complexe, ardu, mais combien fascinant.

2. LA SOCIÉTÉ POST-INDUSTRIELLE, SOCIÉTÉ D'INFORMATION, DE CONCERTATION ET DE PARTICIPATION

Tous s'accordent sur l'émergence d'une nouvelle société. Les faits parlent par eux-mêmes. Ce que tous cherchent, c'est un modus vivendi dans ce nouveau contexte. Les gouvernements et les entreprises peuvent-ils entreprendre des réformes, lancer des programmes, sans bien solliciter l'acceptation et la participation des publics impliqués par la mise en place des équipements qui en découlent. Que ce soit une politique de revalorisation d'un centre-ville, de traitement et recyclage des résidus industriels toxiques, d'épuration des eaux usées, d'exportation d'électricité ou encore de développement d'une aluminerie, les impacts sont importants et multiples et le temps de l'improvisation dans leur implantation est révolu.

Pour bien piloter des projets souvent controversés, il faut s'assurer de la présence d'un certain nombre de conditions préalables sinon on risque de se buter à des coûts élevés, des retards indus et des bouleversements sociaux souvent dramatiques.

La volonté politique, la qualité de la technologie, la rigueur des études techniques et socio-économiques, la compétence en gestion de projets, les mesures de mitigation et de compensation sont tous des facteurs importants. Cependant, la concertation et la participation des divers intervenants sont des facteurs tout aussi importants. Si un problème sérieux survient concernant un seul de ces facteurs, le projet ne se réalisera jamais ou accusera un retard considérable et coûteux.

Pensons au projet d'équipement hydro-électrique sur la rivière Hudson de la compagnie américaine Con Edison qui a coûté plusieurs millions de dollars inutilement en prenant quinze (15) ans à s'implanter ou encore pensons aux efforts qui durent depuis six (6) ans en Ontario pour l'implantation d'un centre de traitement de résidus industriels et on comprendra qu'il est urgent de s'intéresser à l'élaboration d'une méthode pour solutionner ce problème.

Ceci implique de bien identifier ce qui caractérise la société actuelle. Parmi une dizaine de facteurs influents, l'importance des media, la scolarisation et le développement d'une conscience écologique, le désir de participation qui en découle, la prolifération des associations et groupes

d'intérêt, la législation affectant l'implantation des grands projets sont des points à examiner avant d'élaborer une méthode ou une façon de faire à cet égard.

Ce qui semble évident, c'est qu'on hésite, qu'on procède par essais et erreurs ; la problématique étant, d'une part, l'évidence de la nécessité de la concertation et, d'autre part, l'absence d'attitude, de valeurs, de comportements et de mécanismes favorisant cette concertation. Le citoyen a perdu confiance dans l'entreprise et dans les gouvernements. Ces derniers s'impatientent, trouvent le processus paralysant et tentent parfois de l'éviter. Après avoir perdu beaucoup de temps et d'argent, on se retrouve dans une situation d'immobilisme.

Il serait malvenu d'imposer des institutions et des systèmes pour régler la situation. Il faut, au préalable, un partage des valeurs et une philosophie commune pouvant déboucher sur un consensus. Un consensus où chacun doit faire un effort réel en temps et énergie pour finalement y gagner beaucoup. Cette philosophie est basée sur la croyance en l'information, la concertation et la participation et que ces activités sont un avantage social, qu'elles représentent un préalable à une nouvelle qualité de vie et qu'elles sont vitales au maintien des caractéristiques démocratiques de nos différents environnements.

3. LES ENJEUX, LES OBJECTIFS ET LES RÔLES DE L'INFORMATION, DE LA CONCERTATION ET DE LA PARTICIPATION

Pour le promoteur, informer, concerter et faire participer ne doit pas être vu comme un mal temporaire. S'il procède correctement, il peut éviter des coûts, des retards et bonifier son projet.

Pour les gouvernements, ces mécanismes représentent un instrument inhérent à nos valeurs démocratiques. C'est un véhicule idéal pour obtenir des avis et expliquer ses politiques et objectifs.

Pour le citoyen, cela lui permet d'être au courant des faits du projet et d'assumer ses responsabilités civiques et d'agir comme élément de surveillance d'un processus très fragile. Même si son rôle est limité par manque de disponibilité, lui seul peut donner un avis sur les projets qui sont destinés à son environnement. Plusieurs exemples ont fait la preuve de la nécessité d'une participation des citoyens pour améliorer les projets et les politiques.

Pour les media, l'évolution technologique leur a donné des moyens de haut niveau. Leur apport et leur responsabilité sont doublement importants et stratégiques.

4. UNE FAÇON DE FAIRE

Les premières confrontations dans ce contexte moderne ont résulté souvent en procédures juridiques, en abandon de projets et toujours en frustrations pour les principaux intervenants. Les expériences axées sur une et leur approche légaliste et formelle de la concertation et de la participation restreignent les facilités d'échange et le développement d'un consensus ou compromis.

Il s'agit donc d'intégrer les divers intervenants dans la poursuite d'objectifs communs qu'ils soient socio-économiques, politiques, environnementaux, techniques ou autres.

Par définition, cette multi-disciplinarité nécessite une approche professionnelle correspondante. Il est important de bien saisir les aspects de communication, de relations publiques, politiques, environnementaux et techniques de ces projets.

Une gestion intégrée assurant le respect des particularités de chaque discipline est une façon de faire. La réalisation d'un projet est impossible sans une méthode et le respect de certaines lois en implantation ou gestion intégrée de projet :

- L'unicité de message en communication est une des lois fondamentales si on veut créer une crédibilité chez l'émetteur, que ce soit un gouvernement, un promoteur ou une association de citoyens.
- La chronologie des actions assure une démarche graduelle et authentique.
- La préparation de bons dossiers scientifiques et la disponibilité de spécialistes vulgarisateurs sont vitales pour assurer une démarche d'acquisition de connaissances.
- La qualité organisationnelle des responsables de l'implantation du projet permet l'efficacité des échanges.
- La disponibilité et l'ouverture du promoteur garantissent la fiabilité et la crédibilité de l'échange.
- Le respect du contexte politique et organisationnel évite chez le responsable des gestes impulsifs et improvisés.

Voilà quelques exemples de conditions de réalisation à la base d'une bonne information, concertation et participation.

Finalement, le test que doit passer tout projet qui prétend assurer un processus authentique est l'obtention pour la majorité des intervenants d'un gain quelconque. Que ce soit la création d'un comité conjoint de surveillance pour les citoyens, de la réalisation d'une politique pour un gouvernement et du démarrage d'une usine pour un promoteur, chacun doit y trouver son compte.

LES TABLEAUX SUIVANTS ILLUSTRENT LES OBJECTIFS, LES RÔLES, LES LOIS ET LA MÉTHODE POURSUIVIS PAR COGESULT.

(1) Référence : As the world becomes more technically unified, life in an ivory tower becomes increasingly impossible. Not only so the man who stands out against the powerful organizations which control most of human activity is apt to find himself no longer on the ivory tower... but in the dark and subterranean dungeon upon which the ivory tower was erected. Fred H. Knelman dans Nuclear Energy, Hurtig Publishers, Edmonton, 1976, page 237.

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COGESULT

Gestion intégrée de projets
OBJECTIFS DU CONSULTANT

1. **Intégration et interaction harmonieuse des objectifs:**
   - environnementaux
   - techniques
   - économiques
   - sociaux
   - politiques
2. **Réalisation du projet dans les meilleurs délais, à moindre coût en respect de l'image du client et des intervenants.**

COGESULT

Gestion intégrée de projets
RÔLE DU CONSULTANT

1. **Agent neutre**
   Privilégie le client en se préoccupant des intérêts des autres intervenants.
2. **Agent pacificateur**
   Absorbe les situations de tension et évite les points de non-retour.
3. **Agent médiateur**
   Assure la crédibilité du processus par une participation authentique.
4. **Agent coordonnateur-organisateur**
   Exerce un suivi serré des événements par une présence et une disponibilité continues.

COGESULT

Gestion intégrée de projets
LOIS D'IMPLANTATION DE PROJETS

I La loi des gains paritaires « Win Win Philosophy »

II Stratégie de changement — Chronologie des actions.

III Unicité de direction et de message

IV Accord avant obligation (Deutsch)

V Fragilité des mouvements d'opinion

VI Rythme du projet déterminé par contexte (Etzioni)

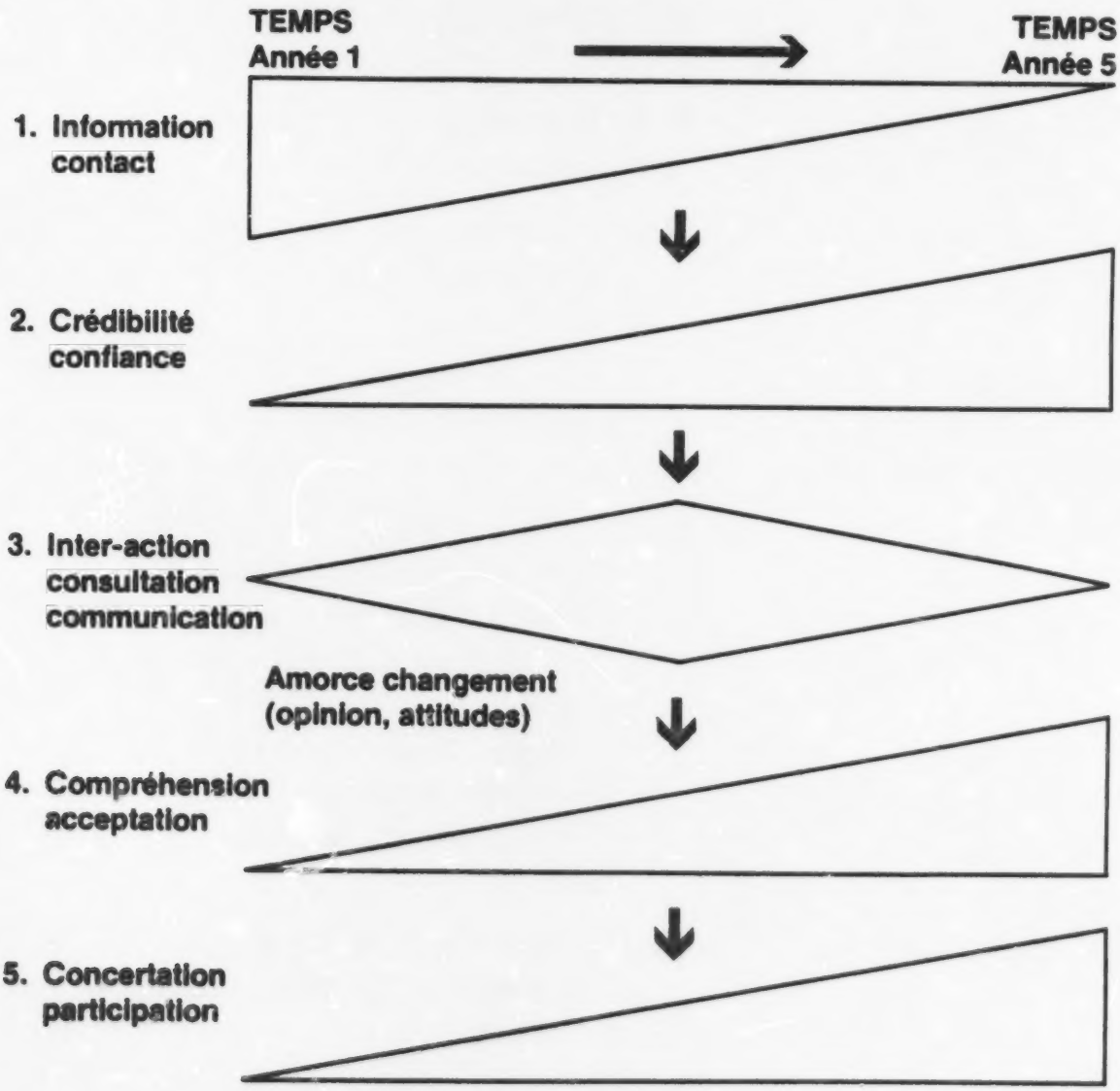
COGESULT

Gestion intégrée de projets
MÉTHODE

1. Cueillette de données	■ Profil socio-économique, politique et historique
2. Élaboration	■ Problématique et stratégie d'intervention
3. Élaboration	■ Dossiers techniques, hypothèses et schéma d'accord
4. Mise en place de mécanismes organisationnels	■ Comité stratégie ■ Comité coordination ■ Comité média
5. Élaboration	■ Programme d'information - Rencontres informelles - Sessions d'information techniques et populaires - Kiosques - Campagne d'information auprès des média - Lettres personnalisées - Etc.
6. Lancement	■ Processus authentique d'information, de négociation et d'acceptation

COGESULT

Stratégie de changement
CHRONOLOGIE DES ACTIONS



ÉTUDE HYDROGÉOLOGIQUE DU SITE D'ENFOUISSEMENT STABLEX À BLAINVILLE

PAR: Colette Rainville, Géologue
Tecsult Inc.
Experts-Conseils

1.0 INTRODUCTION

À la fin de 1975, le gouvernement du Québec adoptait un règlement sur la gestion des déchets liquides. Une partie de ces déchets, les déchets liquides organiques, a pu être contrôlée étant donné la disponibilité de centres de recyclage et d'élimination. Cependant, les déchets liquides inorganiques n'ont pu jusqu'à maintenant être contrôlés.

Les efforts du ministère de l'Environnement du Québec pour amener les industries à solutionner elles-mêmes ce problème, se sont avérés inefficaces. Suite à cet échec, le ministère de l'Environnement a confié au Centre de Recherche Industrielle du Québec, le mandat d'étudier les différents procédés de traitement des résidus inorganiques industriels.

L'étude du Centre de Recherche Industrielle du Québec a fait ressortir que la solidification des résidus inorganiques industriels par le procédé "Sealosafe" de la compagnie Stablex Canada Ltée, est le procédé qui peut traiter le plus grand nombre de déchets sans danger de contamination de l'environnement et à un coût relativement bas.

Suite à l'adoption de cette alternative, le ministère de l'Environnement a procédé dans un premier temps à la recherche d'un emplacement approprié pour le Centre de Traitement et le site d'enfouissement.

Selon certains critères de faisabilité technique et socioéconomique et à la suite d'études géotechniques et d'évaluation des répercussions environnementales, l'emplacement de Blainville fut retenu.

Une fois la sélection du site effectuée, des études de convenance ont dû être réalisées avant de procéder à l'aménagement du site d'enfouissement.

2.0 ÉTUDES DE CONVENANCE

Le 2 juin 1981, ABBDL-TECSULT était mandaté par Stablex Canada Ltée, d'effectuer une étude hydrogéologique sur le site du Camp Bouchard à Blainville.

L'étude devait se conformer aux termes de référence fournis par le ministère de l'Environnement. Le programme de l'étude fut préparé en fonction des termes de références puis soumis pour approbation au ministère de l'Environnement du Québec et entériné par Environnement Canada en date du 8 juin 1981.

Le programme d'étude présenté comportait les étapes suivantes:

- Recherche de la documentation géologique et hydrogéologique existantes.

- Inventaire des usagers de l'eau souterraine à l'intérieur d'un rayon de 2 km du site d'enfouissement.

- Relevé de sismique réfraction.

- Installation de piézomètres dans les différentes unités hydrostratigraphiques.

- Carottage géophysique.

- Détermination des paramètres hydrauliques des formations aquifères à l'aide de puits d'essai dans le sable de surface et dans le roc.

- Échantillonnage de l'eau souterraine et de l'eau de surface.

- Relevé topographique.

- Étude hydrologique.

Au total, 7 puits d'essais, 11 puits témoins, 12 piézomètres, 6 sondages stratigraphiques, 3,5 km de sismique réfraction et 30 diagraphies furent effectués.

2.1 Géologie

2.1.1 Géologie du socle rocheux

La région du Camp Bouchard repose sur des roches sédimentaires d'âge Ordovicien composées en majeure partie de calcaires et de dolomies.

Les forages et sondages exécutés sur cette partie du Camp Bouchard ont recoupé un calcaire cristallin gris à litage subhorizontal appartenant au groupe Chazy déjà identifié dans la région (Clark, T.H., 1972).

La topographie du roc interprétée à partir des forages et sondages réalisés au cours de l'étude ainsi que de l'information compilée de diverses études hydrogéologiques et géotechniques effectuées dans la région révèle une protubérance du socle rocheux au chemin de la Côte St-Louis où le roc est subaffleurant dans la partie nord pour s'approfondir vers le sud formant un canyon à versants excarpés. Vers la zone d'enfouissement le roc accuse une dépression.

2.1.2 Géologie des dépôts quaternaires

Trois types de dépôts ont été identifiés et décrits comme suit:

- à la base une couche de sable et gravier silteux. L'épaisseur de cette couche varie de 2 à 13 m dans un rayon de 1 km du centre du site réservé à Stablex.

- une couche d'argile marine dont les épaisseurs variables sont croissantes du Chemin de la Côte St-Louis vers le nord-ouest. D'après les granulométries, cette argile est décrite comme une argile silteuse grise avec des traces de sable fin et de coquillages.

- surmontant la couche d'argile, une couche d'épaisseur variable de 2,5 à 3 m de sable fin uniforme et présentant des traces de silt a été identifiée dans tous les forages et sondages effectués sur le site du Camp Bouchard

2.2 Hydrogéologie

2.2.1 Nappe phréatique

Un relevé détaillé de la piézométrie de la nappe phréatique a été effectué et a démontré la position de deux crêtes, ou lignes de partage des eaux, à l'intérieur de la région à l'étude. Ces deux axes représentent des surélévations de la surface de l'eau, laquelle s'écoule de part et d'autre de l'axe, en s'éloignant de celui-ci. La présence d'une de ces crêtes entre le Chemin de la Côte St-Louis et le site d'enfouissement réservé à Stablex, constitue donc une protection efficace de la formation aquifère dans les dépôts meubles rencontrés le long du Chemin de la Côte St-Louis en empêchant la migration des eaux du site réservé à Stablex vers le Chemin de la Côte St-Louis.

La vitesse de migration de l'eau souterraine dans les sables de surface d'après la conductivité hydraulique obtenue à partir des essais de pompage à débit constant et des essais à charge d'eau variable et selon le gradient hydraulique pour la région située entre les deux lignes de partage des eaux peut varier entre 4×10^{-5} et $7{,}7 \times 10^{-8}$ cm/s. Pour fins de calcul, la porosité des sables fins silteux a été estimée à 0,35.

TABLEAU 1 : CARACTERISTIQUES HYDRAULIQUES DES AQUIFERES

Identification du puits	Transmissivité kD (m^2/j)	Coefficient d'emmagasinement S	Conductivité hydraulique k (cm/sec)	Méthode d'analyse
R-12*	329,3	$1,4 \times 10^{-4}$	$1,3 \times 10^{-1}$	Theis
	287,8	$2,0 \times 10^{-2}$	$1,1 \times 10^{-1}$	Jacob
R-22	126,0	$2,0 \times 10^{-4}$	$4,9 \times 10^{-2}$	Theis
	79,7	$4,2 \times 10^{-4}$	$3,1 \times 10^{-2}$	Jacob
R-32	87,9	$1,9 \times 10^{-1}$	$2,4 \times 10^{-2}$	Theis
	116,8	$1,2 \times 10^{-1}$	$3,2 \times 10^{-2}$	Jacob
S-12	18,6	$1,2 \times 10^{-3}$	$9,5 \times 10^{-3}$	Theis
	24,5	$9,0 \times 10^{-4}$	$1,2 \times 10^{-2}$	Jacob
	25,9	-	$1,3 \times 10^{-2}$	Rabattement résiduel
S-22	7,6	$9,3 \times 10^{-3}$	$5,6 \times 10^{-3}$	Theis
	9,8	$3,1 \times 10^{-2}$	$7,1 \times 10^{-3}$	Jacob
S-32	15,7	$2,5 \times 10^{-2}$	$9,3 \times 10^{-3}$	Theis
	15,2	$2,7 \times 10^{-2}$	$9,0 \times 10^{-3}$	Jacob
S-42	287,6	$7,6 \times 10^{-3}$	$8,6 \times 10^{-2}$	Theis
	279,9	$7,4 \times 10^{-3}$	$8,4 \times 10^{-2}$	Jacob

* Les puits d'observation identifiés "R" ont été utilisés pour le calcul des caractéristiques hydrauliques du roc et ceux identifiés "S" pour celles du sable.

Les caractéristiques hydrauliques de la portion saturée des sables fins plus ou moins silteux varient appréciablement entre les sondages aux sites S-12, S-22 et S-32. Le tableau 1 présente les valeurs des caractéristiques hydrauliques obtenues par les méthodes de Theis et Jacob à partir des données de pompage.

2.2.2 Aquifère du Chemin de la Côte St-Louis

Le milieu granulaire saturé qui constitue la formation aquifère à nappe libre alimentant les résidents du Chemin de la Côte St-Louis est constitué de sable et gravier silteux. Ces dépôts reposent directement sur le roc calcaire tel qu'il a été mis en évidence par les sondages.

Les caractéristiques hydrauliques de la formation aquifère ont été calculées à partir des données de l'essai de pompage à débit constant effectué au site S-4 (tableau 1). Le coefficient d'emmagasinement est caractéristique d'une nappe semi-captive.

La formation aquifère rocheuse (calcaires ordoviciens) qui alimente environ 70% des usagers inventoriés sur le Chemin de la Côte St-Louis est aussi caractérisée par une nappe libre tel qu'il a été mis en évidence lors de l'analyse des données de l'essai de pompage au site R-3 (tableau 1).

2.2.3 Dépôt d'argile

Les données sur les paramètres hydrauliques de la couche d'argile proviennent de trois sites. À chacun de ces sites, le consultant a fait exécuter une série d'essais de perméabilité in situ à charge d'eau variable. Des échantillons ont été prélevés à différentes profondeurs pour permettre la mesure des coefficients de perméabilité.

De plus, l'installation de piézomètres du type Casagrande, à différentes profondeurs dans l'argile, a été effectuée à chacun des sites mentionnés ci-haut.

L'interprétation des résultats indique des conductivités hydrauliques horizontales mesurées en place de l'ordre de 10^{-6} cm/s et des coefficients de perméabilité verticale mesurés en laboratoire de l'ordre de 10^{-8} cm/s pour la partie inférieure du dépôt d'argile.

Les gradients hydrauliques verticaux (iv) ont été calculés et sont résumés comme suit:

- i vertical pour la totalité du dépôt au site P-1

  iv(P-1) - 0,42

- i vertical au site P-2:

  iv(P-2) - 0,42

Nous considérerons seulement cette valeur comme étant caractéristique de la partie la plus épaisse du dépôt d'argile.

La piézométrie observée dans les piézomètres installés à différentes profondeurs permet de conclure que le gradient hydraulique horizontal dans la zone supérieure du dépôt tend à se confondre à celui de la nappe phréatique dans le sable de surface.

Le gradient hydraulique horizontal dans la partie inférieure du dépôt, près du contact avec les sables graveleux, tend à se confondre avec la piézométrie observée dans le sable graveleux et dans le roc. Il faut noter ici qu'il existe un lien hydraulique entre la partie supérieure du roc et le sable graveleux et que la piézométrie de chacun est à toute fin pratique la même.

La porosité (n) de l'argile mesurée à partir de 8 essais de consolidation varie entre 51% et 66% pour une moyenne de 60%.

Le degré de saturation de l'argile est de 100% et la vitesse de migration verticale calculée à partir de la loi de Darcy en utilisant une perméabilité moyenne de 2,5 x 10^{-8} cm/s est de 1,75 x 10^{-8} cm/s pour le dépôt.

Ceci implique que le temps de migration à travers une couche d'argile de 12 mètres d'épaisseur excède 2000 ans.

Il appert donc que ces temps de migration seront approximativement doublés pour traverser les zones les plus épaisses du dépôt.

En conclusion, la vitesse de migration verticale à travers le dépôt d'argile est du même ordre de grandeur que le critère du ministère de l'Environnement du Québec (10^{-5} m/j).

2.2.4 Nappe captive

Les résultats des essais de pompage aux sites R-1 et R-2 montrés au tableau 1 révèlent une formation aquifère à nappe captive localisée immédiatement sous le dépôt d'argile. Cette formation comprend entre 2,5 et 13 mètres de sables graveleux silteux et les premiers mètres du roc. Ce lien hydraulique a été mis en évidence par la mesure des niveaux piézométriques qui sont sensiblement les mêmes dans les deux unités perméables.

Les résultats d'un essai à charge d'eau variable au définissent une conductivité hydraulique de $1,4 \times 10^{-2}$ cm/s pour un horizon de sable et gravier à quelque 12 mètres de

profondeur. Il appert donc que cette conductivité hydraulique est comparable à celle du roc.

La zone la plus perméable du roc se retrouve dans les trois premiers mètres tel que mis en évidence lors de l'installation des puits d'observation.

La piézométrie de la nappe captive a démontré que les formations aquifères rocheuses de la région de la Côte St-Louis sont situées en amont du site réservé à Stablex.

En conclusion, le risque de contamination des puits des usagers de l'eau souterraine de l'aquifère rocheux de la Côte St-Louis est nul compte-tenu de la direction de l'écoulement de l'eau souterraine.

3.0 HYDROCHIMIE

3.1 Méthodologie d'échantillonnage

Au total 26 échantillons d'eau ont été prélevés et analysés suivant les méthodes d'échantillonnage et d'analyse suggérées dans Standard Methods for the Examination of Water and Wastewater, 1975.

L'eau de l'aquiclude étant difficilement soutirable dans le court intervalle de temps de l'étude, l'analyse de cette eau a été reportée à une date ultérieure. À cet effet, le puits D-1 a été aménagé à 13 m dans la couche d'argile et crépiné sur ses 3 m inférieurs. Ce puits doit fournir les quantités d'eau nécessaires pour effectuer ces analyses au cours du suivi environnemental.

3.2 Interprétation des résultats

Les échantillons ont été classés d'après leur provenance en trois catégories: l'eau souterraine du roc, des dépôts meubles superficiels et l'eau de surface prélevée dans les fossés et marécages.

Les rapports ioniques caractéristiques de chacune des catégories d'eau souterraine sont présentés au tableau 2 et confirment les données hydrogéologiques.

TABLEAU 2 - RAPPORTS CHIMIQUES CARACTERISTIQUES DES EAUX SOUTERRAINES

Numéro du puits	Mg/Ca	SO_4 /Cl
ROC		
#10 de l'inventaire	0,62	1,63
R-1	2,41	0,17
R-2	0,48	0,18
R-3	0,10	1,40
DEPOTS MEUBLES		
#32 de l'inventaire	0,13	1,67
S-2	0,10	4,00
S-1	0,25	2,45
S-3	0,10	1,85
S-4	0,08	0,22

D'après les résultats d'analyses, les phénols, les huiles et graisses, l'Aroclor et les pesticides sont tous en deça des limites acceptables pour l'eau potable.

La qualité bactériologique des échantillons de l'eau souterraine s'est avérée acceptable. Dans le roc, l'échantillon prélevé dans R-3 en nappe libre est le plus contaminé. Dans les dépôts meubles, c'est l'échantillon prélevé au puits #32 de l'inventaire et le puits S-3 où on a décelé la présence de bactéries.

4.0 CONCLUSION

4.1 Drainage et étanchéité des cellules

Les mesures suivantes doivent être adoptées pour le drainage et l'étanchéité des cellules d'enfouissement:

- des fossés de drainage doivent être excavés pour intercepter et canaliser les eaux de ruissellement.

- les cellules doivent être protégées entièrement d'une couverture étanche pour éviter que le ruissellement de surface n'entre en contact avec le stablex.

- chacune des cellules sera entourée sur tout son périmètre d'une coupure efficace de façon à constituer une seconde ligne de défense contre les infiltrations d'eau extérieure.

- Compte tenu de l'épaisseur minimale d'argile de 12 mètres recommandée par le ministère de l'Environnement, il s'avère qu'une partie seulement du site satisfait à ce critère.

- La couverture devra être pourvue d'une couche additionnelle de terre arable, favorisant le développement de la végétation après l'ensemencement. Cette reconstitution, même avec la surélévation, laissera une apparence s'intégrant bien au paysage environnant et constituera une solution optimale au problème de l'enfouissement du stablex dans son état solide.

5.0 PROGRAMME DE SURVEILLANCE

Stablex Canada Ltée poursuit présentement un programme d'échantillonnage mensuel de l'eau souterraine du sable, de l'argile et du roc ainsi que de l'eau de surface des fossés afin de suivre la qualité de ces eaux.

Ce programme d'échantillonnage et d'analyse se poursuivra durant toute l'opération du site. À partir de ce moment, les ouvrages et la méthodologie d'échantillonnage seront intégrés au programme de surveillance de la qualité des eaux.

5.1 Aménagement des stations d'échantillonnages

L'aménagement des premières stations d'échantillonnage s'est effectué au cours de l'été et de l'automne 1982.

Des puits témoins ont été aménagés dans le sable de surface, dans l'argile et dans le roc.

Les puits témoins ont été aménagés en amont et en aval du site d'enfouissement selon les directions d'écoulement déterminées dans le sable de surface et dans le roc au cours de l'étude hydrogéologique.

L'aménagement des puits a été effectué de façon à empêcher toute contamination pouvant provenir d'un horizon adjacent, de la surface ou du puits lui-même.

REGIONAL MUNICIPALITY OF OTTAWA-CARLETON
WASTE MANAGEMENT MASTER PLAN

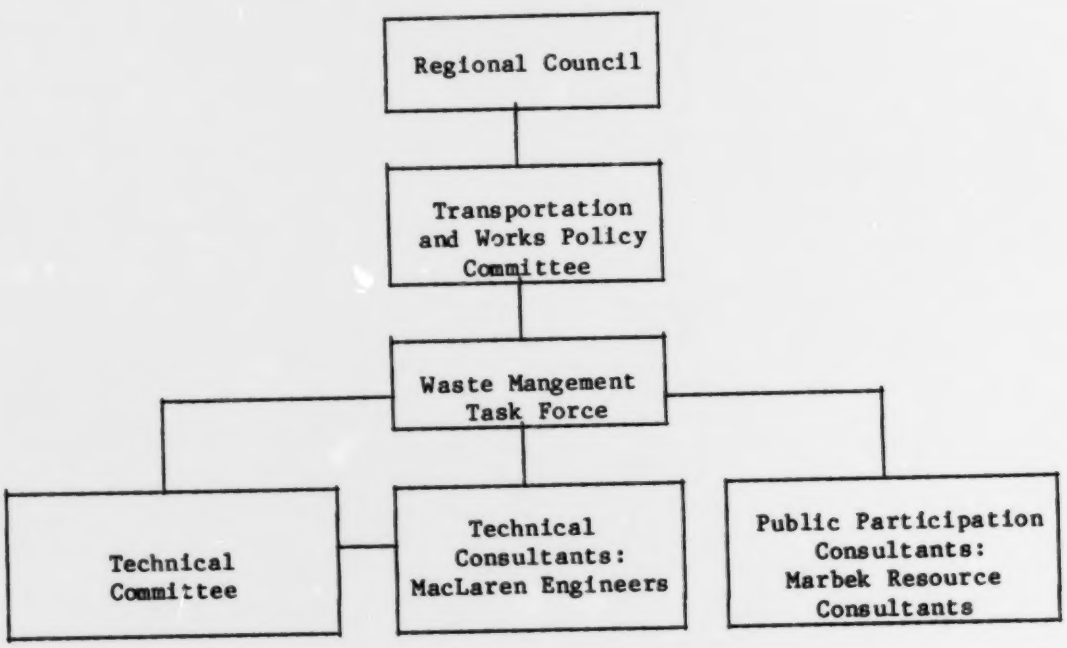
H.W. Cornfield, P.Eng.
MacLaren Engineers Inc.

INTRODUCTION

In 1973 a major study on Solid Waste Management for the National Capital Area recommended a Solid Waste fired-steam generating plant, a transfer station in Hull, and a major sanitary landfill in the Region of Ottawa-Carleton. Subsequently, the Trail Road landfill site was opened in 1980. Also in co-operation with other agencies, the Region undertook an intensive review of the proposed energy from waste project in 1982. Based on public reaction to the study outcome, Regional Council decided to develop a solid waste management master plan for a 25 year period from 1987 through 2011.

The Regional Municipality of Ottawa-Carleton, in conjunction with the Ontario Ministry of the Environment, launched the WastePlan process in December 1984. WastePlan is a two-year process involving technical studies and public participation, all leading to decisions on how best to handle our wastes. Regional Council has allocated WastePlan a budget of approximately $650,000, close to one third of which has been earmarked for activities designed to encourage, gather and record public input on waste management. The Ontario Ministry of the Environment provides 50% of the funding for WastePlan.

The following chart summarizes the levels of Regional government, their appointed committees and the consultants responsible for directing WastePlan.



The study is being undertaken so that the report will qualify as an environmental assessment under the Environmental Assessment Act. Following the guidelines for an environmental assessment the master planning process has been structured into three stages:

- Stage 1 - Data Collection
- Stage 2 - Development of Master Plan Options
- Stage 3 - Master Plan Formulation

Throughout all stages of the planning process a major program for public participation will be undertaken with the objective to ensure that the public is informed from the outset and to solicit, hear and utilize constructive public opinion.

The Stage 1 report, released in April 1985, addresses the technical issues of the Master Plan in three parts; the existing waste management system, potential waste management options, and waste management assessment considerations.

CURRENT SITUATION

The Region has primary responsibility for the disposal of solid waste whereas collection and transportation of waste remain the responsibility of the area municipalities. Collection is carried out by municipal forces or is contracted out to private haulers. Industrial and commercial solid waste collection is carried out by private haulers.

Disposal is primarily by landfill with the following facilities in operation:

- The Trail Road landfill (Regional) receives 57% of the waste.
- The Rump Site receives 24.3% of the waste.
- The Huneault Site receives 17.5% of the waste.
- Four municipally owned and operated sites at Torbolten, Galetta, Osgoode, and Springhill receive about 1.5% of the waste.
- A small landfill in West-Carleton Township is owned and used by the Town of Almonte from outside the Region.

The Region enjoys a relatively high level of interest and activity in recycling. Current and recent past activities include:

- Federal Government - recycles fine grades waste paper, waste oils, reclaimed silver, some special/hazardous wastes, and government surplus items
- Cascade Paper - operate a waste paper processing facility for waste fibre
- Florence Paper - recovers corrugated cartons, over-issue newsprint, post consumer newspapers and fine paper
- City of Ottawa - maintains unmanned drop-off depots for waste glass, tin cans. For selected commercial, industrial, and institutional generators, they collect waste tin and glass. A curbside collection program for waste newsprint ran from September 1980 - January 1982
- Rockcliffe Park - waste newsprint collection
- City of Kanata - operate curbside collection of waste glass using in-home storage containers, tin cans, egg carton recovery, fine paper recovery
- City of Nepean - curbside collection of newsprint
- The Recycle Store - recovers, repairs and resells discarded white goods

. Local Scrap Dealers - handle a large volume of a wide range of materials of value.

In 1984 approximately 35,000 tonnes of waste were recovered from these recycling operations.

Although landfilling is the primary means of disposal in the Region, there are 23 active waste incinerator sites within the Region, most of which are owned and operated by hospitals and the Federal Government. Approximately 500 tonnes of wastes were incinerated in 1984.

The current practice for disposing of special wastes including construction demolition, biomedical, sewage sludge and septage. Industrial liquid and hazardous wastes are also dealt with in the study.

In total 473,500 tonnes of Municipal and construction/demolition waste were generated in 1984 with 432,050 tonnes going into area landfills. In addition waste from the Town of Rockland and Lanark County, outside the Region is deposited in area landfills.

Current generation rates for residential and light commercial wastes and for commercial and industrial wastes were established:

. residential and light commercial - 1.04 kg/person/day
. commercial and industrial - 1.21 kg/employee/day

Projected waste quantities for residential and light commercial wastes and for commercial and industrial wastes to the year 2011 were also prepared.

Existing Landfills

An assessment of all existing landfill sites was completed and each site was analysed as to location and geological setting, site history, site certification, operating procedures, remaining capacity, environmental impact, ongoing operation and close-out, monitoring and contingency planning and potential for continued use and expansion.

The privately owned Huneault landfill site located on the Navan Road in Gloucester started in 1960 as a rural dump. Since 1982 it has been reported to be receiving clean demolition/construction waste and some clean commercial/industrial wastes. The Ontario Municipal Board, following a hearing in November 1984, directed Gloucester Council to permit the operation of the landfill site for the disposal of construction rubble and miscellaneous inert material in accordance with the Ministry's license.

The site is expected to last until the mid-1990s based on the current rate of filling. On completion, the owners propose to develop the site into a golf course. There is no potential for expansion of the Huneault Site.

The privately owned Rump landfill started in 1971 to serve a population of about 3,000. By 1980 the service area included several municipalities in Lanark County. At the present, the site serves both contract haulers from within and outside of the Region. In 1975, an application was made to enlarge the site from 40 hectares to 80 hectares. In August 1980 the Ministry re-issued a revised provisional certificate for the original 40 hectare parcel of land allowing increased filling.

In January of 1984, a consultant's report on the hydrogeological setting of the site concluded that groundwater contamination had occured beneath the refuse and was migrating off site, and that unless appropriate measures are taken, degradation of local waste resources could be expected.

The assessment of expanded capacity beyond the currently licenced 40 hectares is dependant on ongoing site specific studies relating to the extent and control of off-site migration of leachate. Depending on the willingness

of the owners to implement a proposed plan acceptable to the Ministry of Environment, the site could probably be expanded to 80 hectares and would last 12 to 15 years at current filling rates.

The Region's Trail Road landfill site, is located 8 miles south of Bells Corners in Nepean. The 1973 Master Plan recommended the property be developed and used in conjunction with a central waste-fired incinerator. The new site approval was granted on this basis and the site was opened in May of 1980 after completing the original landfill site on the opposite side of Trail Road. On the basis of the design volume and continuing to achieve the current compaction densities the site will last until about 1996.

Between 1977 and 1982 developments in nearby gravel pits led to major changes in the groundwater behaviour which dropped the static water levels by approximately 5 metres. This created a situation where strong downward vertical gradients exist in the surficial deposits beneath the site. Where the clay layer is absent there will be a downward movement of leachate into the deep sand gravel aquifer. Alternative technical approaches to correct the situation are now under review with the Ministry of Environment and final decisions are anticipated shortly.

The assessment of the potential for continued use or of actual capacity of the Trail Road site cannot be made until the outcome of the ongoing site specific studies is known.

Information on costs was obtained by interviewing each area municipality as to their practice and costs, and by discussions with the major private contractors. Solid waste costs are presented on an area municipality basis for the residential sector and for commercial/industrial solid wastes respectively in Figures 1 and 2. In 1984 the total expenditure was in the order of 15 million dollars for all areas of waste management.

WASTE MANAGEMENT OPTIONS

The Stage 1 report provided an overview of waste management options and technologies available to meet waste disposal requirements. From these options and others if identified, the components of the waste management master plan developed in Stage 2 of the planning process were identified. The issues covered deal with trends in waste management with particular emphasis on the 4Rs of waste management reduction, reuse, recycling, and recovery.

The underlying philosophy of reduction and reuse is to produce less waste in the first place and therefore this approach is the most environmentally and economically sound approach to waste management. As such, reduction and reuse initiatives should precede all other options including recycling, waste collection, resource recovery, other forms of waste processing, and final disposal. While this logical progression is sound, and these options have gained widespread acceptance in principal, they have received less than full emphasis in practice and actual reduction in waste volumes for disposal has been limited.

Source Separation/Reduction

The opportunities for residential related reduction and reuse were identified, including product differentiation and retail differentiation, in-home reduce/reuse decisions, and external reuse. Opportunities for reduction and reuse in the industrial commercial sectors were discussed under the broad areas of internal and external decisions.

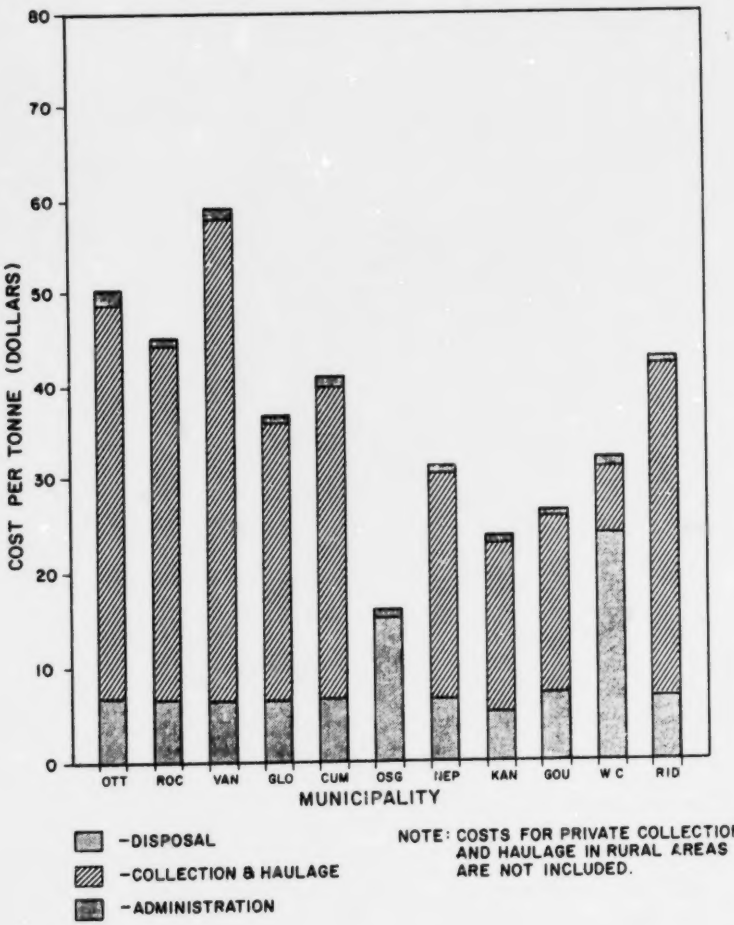


Figure 1

RESIDENTIAL SOLID WASTE
Cost per Tonne
1984 Data

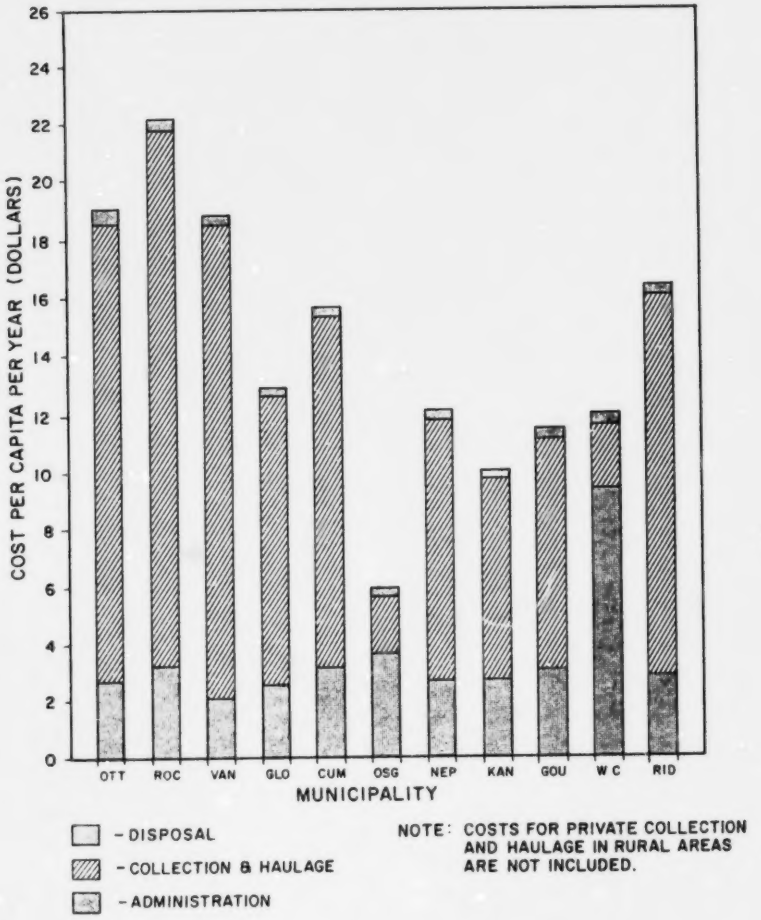


Figure 2

RESIDENTIAL SOLID WASTE
Cost per Capita
1984 Data

Recycling is a realistic alternative to traditional collection and disposal for a portion of the wastes generated. Technical and economic barriers, limited markets for waste materials and geographic location all serve to reduce the impact that it can achieve, however consideration must be given to the relative importance of economic and environmental factors.

An overview of the recycling developments in Ontario indicates an established network of scrap dealers which have primarily focused on the recovery of large relatively homogenious sources of waste in the industrial and commercial sector with annual sales exceeding a half a billion dollars per year. Recent recycling developments focus on materials from marginal sources, including the post consumer municipal waste stream.

All levels of government have been increasing efforts in the area of recovery of materials. A number of factors are apparent in contributing to the slowly increasing improvement in the rate of recovery. These factors include increased waste management costs, wider adopton of averted waste disposal credits, government initiatives to support recycling, the development of more effective recovery techniques and changing trends, attitudes, and initiatives in the public and private sectors. Today however, at least 45% of Ontario's population is being served by a curb side collection of at least one recyclable material.

A number of recycling program options were identified that will be addressed in more detail in the later stages of the master plan process, including such options as drop-off depots, buy-back centres, curb-side collection, commercial/industrial waste recovery programs and salvaging operations.

Processing

Current methods of waste processing and handling which can form complementary components of the overall waste management strategy were described and the advantages and disadvantages of each identified. Alternatives discussed include mechanized resource recovery, composting, incineration, energy recovery from incineration, and transfer stations. Other technologies which are developmental were also discussed including gasification or pyrolosis, hydropulping, size reduction or shredding, and baling.

The successful implementation of a resource recovery and recycling project is dependant on reliable customers and consistent markets for the product. An initial step to any resource recovery or recycling program is the identification of potential markets, and range of market prices for recovered material. An overview of the market opportunities for newsprint, corrugated cartons, fine papers, glass, metal, and waste oil, was provided together with current market prices.

For energy from waste facilities the markets for the product, steam, high temperature hot water or power, must be established at the outset. Stage 1 activities identified existing steam and/or hot water users within the Region who might provide a load for such a proposed facility. Private companies, hospitals, universities and Public Works officials were contacted to identify the potential energy from waste markets. The survey identified 21 potential energy user loads primarily within the urban areas.

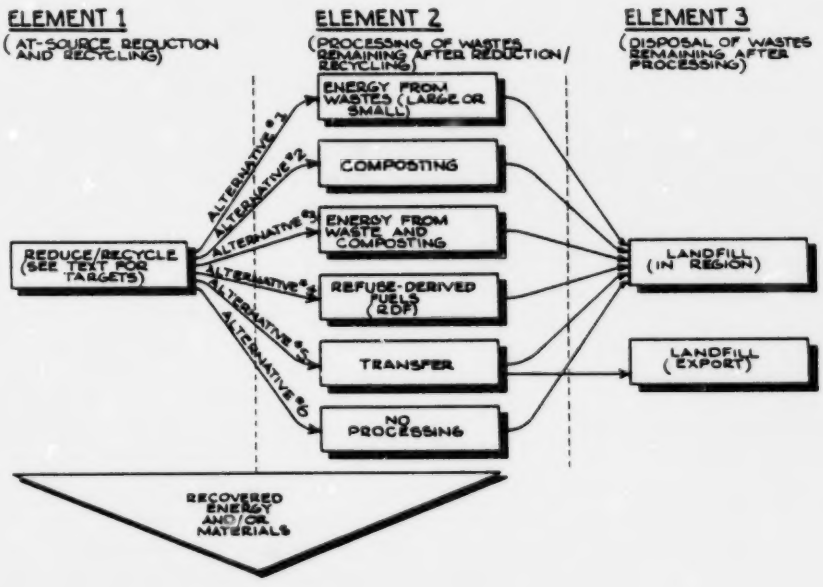
Landfill

For the foreseeable future a portion of the solid waste stream and residues from processing facilities will require land disposal regardless of the processing technology employed. Sanitary landfilling as an engineered method of disposing of solid waste on land in a manner that minimizes environmental hazard was outlined in terms of the technology, the problems and issues of a properly designed and well managed site.

PROPOSED SYSTEM APPROACH

After the publication of the Stage 1 Technical report, a series of public meetings and workshops were conducted to obtain input on the options available. Based on this input and further technical evaluation of available technologies, a three-element waste management system has been proposed for more detailed evaluation and public review in Stage 2 of the process. The three elements and the various alternatives for each element are illustrated below.

WASTEPLAN SYSTEM ALTERNATIVES



During Stage 1 public discussion, very strong public support was expressed for measures that encourage waste reduction and recycling. Furthermore, it was recommended by some members of the public that WastePlan establish targets for reduce/recycle, and then develop programs to meet these targets.

Based on this input, a strong commitment to at-source reduce/recycle is proposed as the first element of the system with the following targets:

- In year one, reduce/recycle measures should reduce the quantities of waste to be handled to 86% of currently projected levels.
- By 2001, reduce/recycle should reduce waste quantities to 66% of currently projected levels.

These projections already assume a continuation of current recycling activity, which recovers about 35,000 tonnes per year. The effort required to meet the stated targets would therefore be in addition to current activities.

The targets refer to municipal waste, both residential and commercial industrial streams. Special wastes, consisting of construction/demolition, biomedical, and sludges from water/sewage treatment plants, are not targeted.

At this time, no specific reduce/recycle programs are proposed, though various possibilities are outlined in the WastePlan Stage 2 Interim Technical Report. Comments and support on reduce/recycle programs that could be implemented are being sought from the public.

The wastes remaining after source reduction/recycling can be processed in a centralized plant(s) to further minimize landfill requirements. Thus far in the study process, it is suggested that one (or more) of four types of technology be used to process Ottawa-Carleton's waste: energy from waste (EFW), composting, refuse derived fuels (RDF), or transfer stations. Mechanized resource recovery plants are not included on a standalone basis. Though mechanical separation may be an appropriate element in an RDF or composting plant, the operating history of such plants, the absence of markets for many waste materials, and the fact it would compete with source separation argues against a "standalone" plant.

In Stage 1 of this study, a market survey identified twenty-one candidate customers for steam from an energy-from-waste plant.

Stage 2 examined the identified energy users in order to determine the suitability of an EFW plant serving the user on a one-to-one basis or as part of a group of users to accumulate sufficient capacity to justify consideration. The economic characteristics of EFW indicated that plants of capacity under 100 tonnes per day are generally not economically viable. Those users that did not have sufficient energy demands either by themselves or as part of a group were eliminated from further study.

Six potential applications or "load groups" for an EFW plant were consequently identified for further study because their energy requirements (on an individual or group basis) represent an EFW plant capacity in excess of 100 tonnes per day and have the possibility for siting the facility within a reasonable distance.

Based on the four technologies described above, five processing alternatives have been proposed for consideration (along with a sixth, "no processing", alternative). Combinations of these alternatives are possible, and the size of plant for each alternative can be varied significantly. The alternatives at this stage in the process, are intended as a focus for public discussion rather than as rigid, "take-it-or-leave-it" packages. The implications of each system are indicated in Table 1.

Even after procesisng the quantities remaining for disposal are considerable in all cases. This is due in part to processing residues, and in part to the fact that most special wastes (such as construction and demolition wastes) are generally not passed through a processing plant prior to disposal.

TABLE 1
PROCESSING ALTERNATIVES

	ALTERNATIVE 1 Energy from Waste (EFW) Large (635 tonnes per day)	Small (200 tonnes per day)	ALTERNATIVE 2 Composting (750 tonnes per day)	ALTERNATIVE 3 EFW + Composting (EFW 270 tonnes per day; compost 400 tonnes per day)	ALTERNATIVE 4 Refuse Derived Fuel (730 tonnes per day)	ALTERNATIVE 5 Transfer to in-Region Landfill	to out-of-Region Landfill (Shawville, P.Q.)	ALTERNATIVE 6 No Processing
Wastes Removed by processing (in millions of tonnes)	3.4 (21%)	1.0 (6%)	2.7 (17%)	2.9 (18%)	1.3 (8%)	--	--	--
Wastes to be land-filled (in millions of tonnes	9.7 (61%)	12.1 (76%)	10.4 (65%)	10.2 (64%)	11.8 (74%)	13.1 (82%)	13.1 (82%)	13.1 (82%)
Cost per tonne for processing and disposal only	$14-22 (for EFW producing steam)	$15-23	$24-34	$22-32	$24-34	Depends on site	$15-25	$13-18

Note 1. All numbers are based on WastePlan projections that 16 million tonnes of waste will be produced over the next 25 years. The reduce/recycle targets outlined above would reduce this amount by 18% over the same period, leaving 82% of the waste stream for normal collection, processing, and disposal. The percentages in each column therefore total to 82% and the quantities to 13.1 million tonnes.

Note 2. Cost figures take account of grants that would be available for some technologies. Due to market uncertainties, no revenue has been assumed from the sale of RDF or compost.

The only disposal option available for Ottawa-Carleton is landfill. The sites currently in use are likely to reach their licensed capacity in the 1990s, with the exact time dependent on whether or when reduction/recycling/processing becomes a major part of Ottawa-Carleton's waste system. WastePlan is therefore considering the possibility of expanding two existing sites and is investigating a number of potential new sites. During Stage 2 a private sector proposal was received from a company in Quebec offering am ajor landfill option. The success of this option is beyond the control of the Region, however, its potential is being watched closely throughout the study process.

WASTE MANAGEMENT SITING CONSIDERATIONS

The Regional Official Plan for the Ottawa-Carleton planning area established major goals for the Region. These goals, together with the requirements of the Environmental Assessment Act, led to the development of the following WastePlan goal.

"To develop waste management facilities and options to meet the waste disposal requirements in a socially acceptable manner and to ultimately determine the locations for various waste management facilities which will cause the least adverse impact upon the physical, natural, social, and cultural environment of the Region of Ottawa-Carleton".

In order to comparatively evaluate waste management facilities or options with respect to the above, comprehensive evaluation criteria must be developed

and applied. In Stage 1 the following preliminary evaluation criteria were presented for public review and comment.

- Public health and safety
- Natural environment
- Social environment
- Cultural environment
- Technical criteria
- Financial Considerations
- Economic Considerations

Each of these categories are broken down into sub-criteria for evaluation purposes in the report.

Waste processing, handling facilities, and landfill sites form the basic components of any waste management system. The search for potential sites is an integral part of the master plan development process. The objective of site selection procedure is to ultimately determine the location for waste management facilities which will cause the least impact to the physical, natural, and cultural environments of the Region.

In Stage 1, the first step in the site screening process was to determine "candidate areas" for waste management facilities. Further investigations were undertaken in Stage 2 to refine candidate areas based on more detailed information and public input to develop a series of potential sites.

The candidate area identification process defined two categories:

- Those suitable for potential waste processing and handling facilities, and
- Those suitable for potential landfill sites.

The candidate areas for potential landfill sites were identified through a regional screening process using a combination of landuse constraints, environmental constraints, and geologic factors to indicate broad areas suitable for the development of landfill sites. The following types of land were excluded from consideration:

- Urbanized areas including rural towns, villages, hamlets and other groups of houses (including a 500 metre buffer around each community).
- Lands within 8 km of major airports or 3.2 km of small airports (based on Transport Canada guidelines).
- Lands owned by the Department of National Defence, the Department of Energy, Mines and Resources, and Agriculture Canada (including the Experimental Farm and the Animal Research Institute).
- Conservation areas within the NCC Greenbelt.
- Other conservation areas identified in the Ottawa-Carleton Official Plan.
- The Ottawa and Rideau River corridors, and flood plains along other rivers in the Region.
- Major wetlands (such as the Mer Bleu).
- Areas considered geologically (and environmentally) unsuited to landfill: deep sands over bedrocks; major granular deposits (eskers, kames and beaches); and certain types of bedrock covered with shallow soils.

In the identification of potential landfill sites, within the candidate areas, the following types of land were excluded from consideration:

- Lands heavily used for agricultural purposes.

- Areas with significant natural environmental features such as large wetlands not already excluded, wooded ravines, extensive wooded tracts, streams with significant fisheries, and complex topographic/drainage areas.
- Most areas with residences, commercial development, and community facilities nearby.
- Cultural features such as recreational/tourist areas, historical sites, and scenic highways/landscapes.

This process resulted in the identification of 12 potential new sites.

Candidate areas for the siting of potential waste processing facilities were identified, taking into consideration the availability of non-residential land uses, such as industrial, major institutional, commercial and open space land uses that could be defined as suitable for potential waste processing and handling facilities. The identification of candidate areas has focused on lands inside the outer limit of the Greenbelt.

Within the urbanized area, the following types of land were tentatively excluded from consideration:

- Areas currently zoned or used for residential purposes.
- Industrial, institutional, or commercial areas with little or no undeveloped land available.
- Mer Bleu, Green Creek, and Stoney Swamp Conservation Areas.
- Department of National Defence Proving Grounds and Defence Research Establishment.
- Areas judged to be poorly served by arterial roadways.

The remaining lands were designated as waste processing candidate areas. In the identification of potential sites within these areas, the following types of land were excluded from consideration:

- Developed land and parcels of undeveloped land less than 2 hectares in size.
- Sites with poor access to arterial roadways.
- Sites where adjacent land uses were judged to be incompatible with waste processing facilities.
- Sites likely to have an impact on scenic drives, NCC parklands, tourist attractions, bicycle paths, etc.

For EFW applications, siting considerations also include the proximity to the energy user, within 2-3 km, and the potential for serving additional nearby potential steam load users not originally considered as part of an existing load group.

This process resulted in the identification of 22 potential sites for waste processing facilities.

FUTURE DEVELOPMENT

A Stage 2 preliminary report has been published which identified:

- 6 alternate management systems
- 15 potential landfills
- 22 potential processing sites.

This range of alternatives and potential sites has been debated at a series of public meetings across the Region. In the near future a series of public workshops will be held to further debate the comparative merits of each and to carry out scoring and ranking of the alternatives. Based on the scoring system, a prioritization of options and sites will evolve and a short

list of alternatives will be developed for more detailed evaluation and comparison in the second half of Stage 2. A further round of public meetings and workshops are planned early in 1986 to again debate and score the short-listed options. Following this round of public input, a recommended "Master Plan" will be developed and documented in the Stage 2 final report scheduled for release in June 1986.

The recommended Master Plan will be presented to Regional Council for debate and approval. Following Council approval of the Master Plan, and thereby approval of the individual elements of the system in general terms, each component will be evaluated and developed in detail in Stage 3 of the Master Plan process. During this stage, site specific impacts will have mitigation measures identified in detail. These will again be debated in public meetings in the specific communities affected. At the end of Stage 3, the Complete Master Plan in detail will be documented in a final report and submitted to Council for approval prior to the implementation phase and the Environmental Assessment Act Process.

DISCOVERY, CLEANUP, AND RESTORATION OF AN ILLEGAL INDUSTRIAL WASTE DISPOSAL SITE

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DISCOVERY

Between May and October 1982, a variety of liquid and solid industrial wastes were illegally dumped on a 40 ha (100 acre) farm located approximately 40 km northwest of Toronto, in King Township (Plate 1). The dumping was terminated in October 1982, after a local resident reported to the Ontario Ministry of the Environment (the Ministry) that vehicles carrying wastes were entering the farm property.

PRELIMINARY INVESTIGATION BY THE MINISTRY

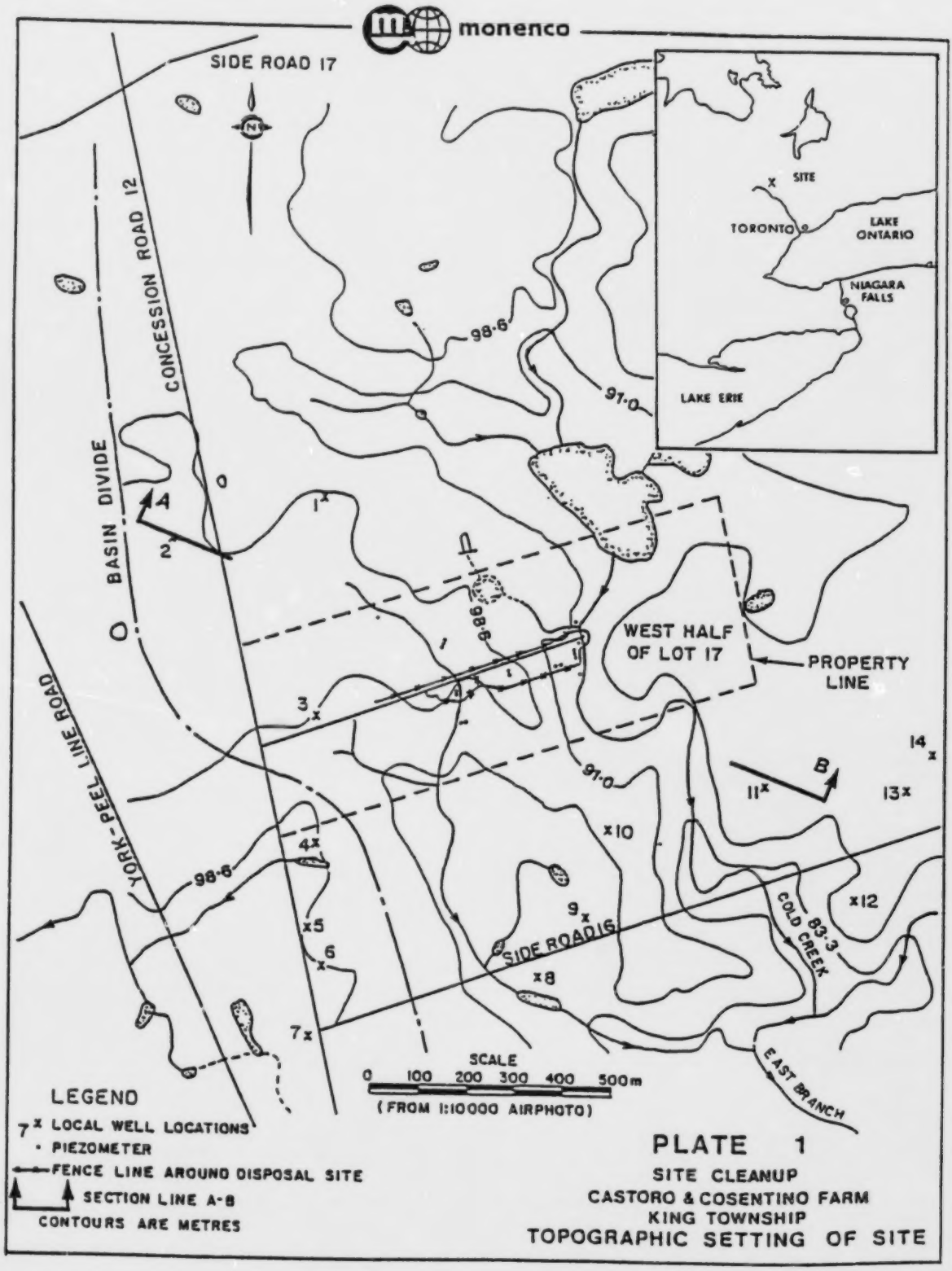
The initial Ministry inspection revealed only the presence of demolition wastes used to construct a road toward the back of the farm property. In March 1983, the Ministry sampled two creeks draining the site and found low concentrations of trichloroethylene (about 0.02 to 0.05 mg/L). These findings prompted further investigation of the farm site and the activities of the waste haulage company suspected of being responsible for the dumping. Water samples were collected for analysis from 14 nearby water supply wells but no problems related to the illegal dumping were detected. The Ministry drilled some shallow test holes, dug several small excavations and conducted preliminary geophysical surveys using a magnetometer to locate buried metal drums that were suspected to have been buried at the site.

During April 1983, several magnetic anomalies were investigated using a backhoe to dig a series of pits and trenches. The excavations revealed large quantities of buried wastes including rubber and commercial wastes and a number of steel drums containing a butadiene-styrene compound (latex). Pools of solvents and used oil mixed with the buried wastes were exposed. The analyses of liquid samples collected from the pools in the excavations revealed acetone, benzene, butadiene-styrene, ethyl benzene, hydraulic oil, toluene, 1,1,1 trichloroethane, trichloroethylene and xylene. The creeks were also sampled again and analyses showed similar trichlorethylene concentrations to those found in March.

LEGAL ACTION

Director's Order

On 30 May 1983, acting under the provisions of the Environmental Protection Act, the Ministry issued a Notice of Intent to the farm property owners followed by a Director's Order on 15 June 1983. The Director's Order required the site to be cleaned up and restored to a pristine state.


monenco
SIDE ROAD 17
CONCESSION ROAD 12
BASIN DIVIDE
YORK-PEEL LINE ROAD
SIDE ROAD 16
COLD CREEK
EAST BRANCH
98·6
91·0
83·3
WEST HALF OF LOT 17
PROPERTY LINE
SITE
TORONTO
LAKE ONTARIO
NIAGARA FALLS
LAKE ERIE
SCALE
0 100 200 300 400 500m
(FROM 1:10000 AIRPHOTO)
LEGEND
LOCAL WELL LOCATIONS
PIEZOMETER
FENCE LINE AROUND DISPOSAL SITE
SECTION LINE A-B
CONTOURS ARE METRES
PLATE 1
SITE CLEANUP
CASTORO & COSENTINO FARM
KING TOWNSHIP
TOPOGRAPHIC SETTING OF SITE

Cleanup Attempt by Owners

After receiving the Director's Order, the farm owners commenced an attempt to clean up the site. The cleanup work performed involved moving wastes from several areas investigated by the Ministry and putting them into a large stockpile on a hill near the centre of the site. No wastes were removed from the site. The removal of wastes from the surface exposed large quantities of both hazardous and non-hazardous wastes, including a number of crushed and ruptured metal drums. The owners' cleanup work continued until 18 July 1983, when the work was stopped because of financial constraints.

Following termination of this work the Ministry determined that the cleanup attempt had created conditions which could increase the contamination of surface runoff and ground water. The Ministry decided that the conditions at the site constituted an environmental emergency and issued a non-appealable Minister's Order on 31 August 1983.

Minister's Order

The Minister's Order was issued to the property owners, the waste haulage company and to the President and sole proprietor of the waste haulage company that was found to be responsible for the illegal disposal of the wastes. The Minister's Order included instructions for completing a two-stage site cleanup and restoration. Stage one was to include the removal of all hazardous materials by 29 September 1983 and stage two was the removal of all remaining non-hazardous wastes and materials by 31 May 1984. The Order further stated that if the named parties failed to carry out the required work, the Minister would undertake the work at the expense of those named in the Order. No action was taken as a result of this Order and, upon giving notice to the named parties, the Ministry took steps to initiate the required cleanup.

MONENCO CONTRACT FOR THE CLEANUP

On 16 September 1983, the Ministry requested proposals from a number of companies to undertake a cleanup of the site. On the basis of a detailed technical and cost proposal, Monenco Limited was awarded the contract for the cleanup. Official authorization to proceed was received on 13 October 1983 and Monenco mobilized on 17 October. The form of the tender and the resulting $910,000 contract between Monenco Limited and the Minister of the Environment was based on unit prices, allowing for variation depending on actual quantities of materials removed from the site. The project was planned to take 10 weeks with substantial completion by 20 December 1983. Final surface grading and hydroseeding were scheduled for the spring of 1984 and were to be carried out under a separate contract based on the Monenco proposal.

SITE CLEANUP

Safety and Medical Protocol

Monenco developed occupational health and hygiene protocols for those who might be exposed to the toxic materials at the site. Prior to commencing removal of the wastes, all staff who might be in contact with the wastes, including staff of the Ministry, Monenco, and Monenco's subcontractor, were

given a medical examination by Monenco's medical officer, a recognized expert in occupational health and safety. They were advised of the potential hazards of the chemicals the Ministry had identified at the site and of the required safety procedures and personal hygiene procedures and precautions to be taken. Washroom and washing facilities were provided and all staff were instructed about personal hygiene procedures including washing up prior to eating or smoking. A shower was provided in case of accidental contact with the toxic materials but it was never required.

Appropriate steps were taken to prevent exposure of staff to hazardous conditions. Protective clothing and equipment were provided for the site staff, depending on their expected level of exposure to the contaminants. This included a complete range of equipment from hard hats, rubber safety boots, gloves and goggles to full PVC suits with full face respirators equipped with cartridges designed to remove dust and organic vapours. Two self contained air packs were available at the site at all times. A Ministry safety officer instructed site staff in the use of the protective clothing and equipment.

To ensure the safety of any site visitors, they were informed of the potential hazards of materials at the site and they were requested to keep well back from active working areas. Frequent visitors were requested to sign medical waiver forms acknowledging that they were aware of the nature of the materials on the site. All working areas of the site were fenced and posted with warning signs to keep out livestock and unauthorized people. As an additional safety precaution, the local fire departments and ambulance services were notified of the type of work to be performed and the types of material to be dealt with, prior to beginning the project. Smoking was prohibited at all times in areas of the site where wastes were being exposed and high capacity fire extinguishers were kept available in these areas. When exposing buried drums and areas of contaminated wastes, an organic vapour detector was used to determine if toxic or hazardous levels of organic vapours might be present.

There were no accidents or injuries during the project and none of the staff reported any illness or medical complaints related to the cleanup. After the cleanup had been completed, follow-up medical examinations demonstrated no deviations that could be attributable to exposure to any of the contaminants.

Project Management

This site cleanup was the first of its type and magnitude conducted in Ontario. Because of the unique nature of the project and the limited data available from the site investigations conducted prior to Monenco's involvement, it was not possible to anticipate all potential problems or variations in the cleanup plan that might be required as the work proceeded. To ensure a quick and efficient resolution of any such problems or questions that might develop, Monenco provided a full-time on-site project manager experienced in a wide variety of industrial cleanups. The Ministry provided a full-time on-site inspector to oversee all aspects of the cleanup. Between them, the project manager and the inspector settled all day to day problems.

Mobilization

When Monenco began work under the Ministry of the Environment contract, the site included three main areas of wastes: the east face of the hill

sloping down to the creek at the extreme east end of the site, a large stockpile of wastes collected by the owners at the top of the hill in the middle of the site, and a smaller discrete area to the west of the stockpile (Plate 2).

Several preliminary tasks were begun at the site immediately. The first task was to establish a co-ordinate grid at surveyed locations 5 m apart around all sides of the site. Additional lines of stakes were put in across the site at selected locations. The grid enabled the accurate recording of locations for soil and water samples, wastes, and ground water observation wells. It also provided the framework for initial and final topographic surveys, conducted to establish ground surface contours before and after the cleanup work.

Prior to any heavy equipment moving on to the site, a structural survey of the property owner's residence and barns was completed to assess the existing condition of the buildings. At the end of the project no structural damage due to the cleanup was found. During the cleanup, the property owner's driveway was used for access and was graded as required to minimize problems with rutting.

To facilitate all weather access, a narrow access road along the north side of the site was upgraded and widened to between 4 and 5 m over a distance of about 600 m. Culverts and ditches for drainage were installed as required. Prior to upgrading, the existing farm lane was surveyed using an EM-31 electromagnetic induction instrument to ensure that no drums were buried beneath the road bed. A number of test pits were dug to check for buried metal at several anomalies and to determine the thickness of the existing rubble. No drums were found in the road bed.

Existing trenches and berms on the site were examined and improved to ensure that there was no potential for contaminated surface water to flow off the site directly into the adjacent creek channels.

Monenco's site office was established near the middle of the site. The office was fully serviced to accommodate the field and project management staff. A small computer was installed to aid in controlling and recording the movement of materials and to produce daily summaries of project costs.

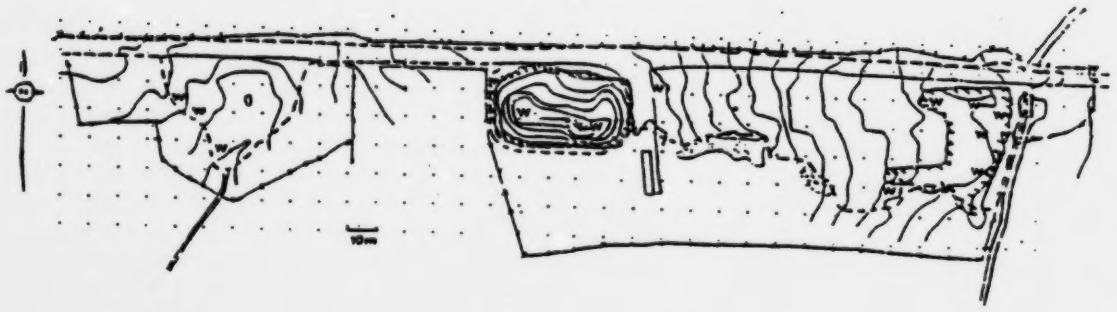
At the entrance to the site, the Ministry established its on-site command post using an emergency response vehicle equipped with radio communcations equipment, office and shower facilities as well as emergency and safety equipment.

A mobile laboratory with gas liquid chromotograph capability was required on the site for the rapid analytical response necessary to direct the cleanup operation. The Ministry elected to use their own mobile laboratory for this work. As the cleanup progressed, a massive quantity of sampling was performed and it became necessary to add a second shift at the lab to maintain the efficiency of the cleanup.

Material Classification and Cleanup Criteria

All wastes, including non-hazardous wastes, were removed from the site as required by the Minister's Order. To dispose of these wastes in a cost effective manner, it was necessary to distinguish between contaminated (hazardous) materials, requiring special treatment and/or disposal, and non-contaminated (non-hazardous) materials which could be disposed of in municipal landfills.

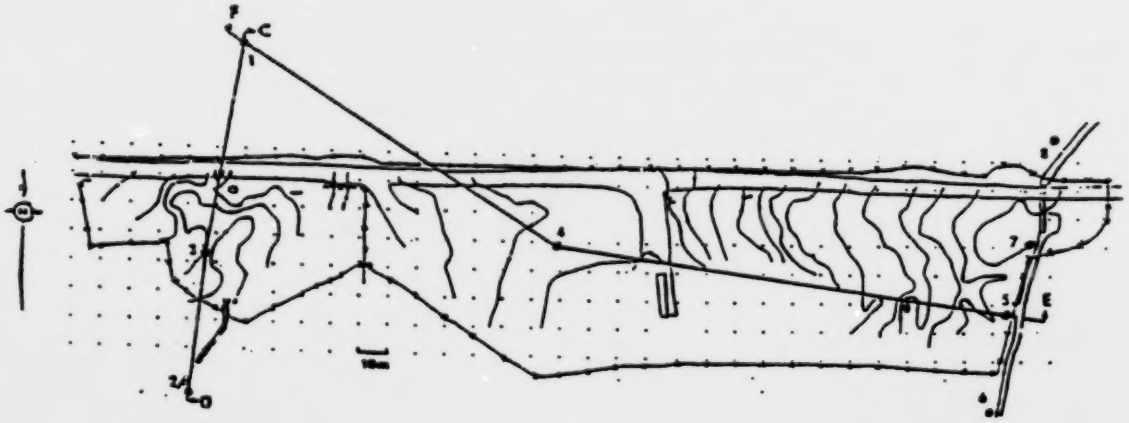
Solid materials containing contaminant concentrations exceeding the following criteria were defined by the Ministry as being hazardous:



LEGEND

---- EXTENT OF WASTE
-91— TOPOGRAPHIC CONTOURS
W DRUM LOCATIONS
FENCE

SITE PLAN BEFORE CLEANUP



LEGEND

● PIEZOMETER NESTS

SITE PLAN SHOWING
POST CLEAN-UP RESTORATION
AND PIEZOMETER NEST LOCATIONS

PLATE 2

SITE CLEANUP
CASTORO & COSENTINO FARM
KING TOWNSHIP

Benzene	2 ppm
Toluene	68 ppm
Xylene	124 ppm
1,1,1 Trichloroethane	12 ppm
Trichloroethylene	6 ppm
Tetrachloroethylene	10 ppm

If any of the above levels were exceeded, the waste or soil was placed in 5.7 m^3 capacity lugger boxes and sent to a licensed industrial waste disposal facility near Sarnia, Ontario. All crushed and ruptured drums were also placed in the lugger boxes.

No specific criteria were established for acetone, ethyl benzene, butadiene-styrene or hydraulic oil since the Ministry considered these to be non-hazardous at the concentrations detected at the site.

Because many of the liquid waste containers had been crushed or ruptured, contamination of some of surrounding soils resulted. Threshold limits below which soils could be considered "clean" and not require removal from the site were established. The maximum permissible residual contamination concentrations for "clean" soil were established by the Ministry as:

Total Hydrocarbons	5 ppm
Chlorinated Hydrocarbons	1 ppm
Toluene	0.5 ppm

These guidelines were developed specifically for application in this project. All non-hazardous wastes and soils (i.e. between the "clean" and the "hazardous" criteria) were disposed of at three licensed non-hazardous waste disposal sites.

Another set of criteria was developed by the Ministry to govern the disposal of contaminated liquids:

Acetone	65.0 mg/L
Benzene	0.01 mg/L
Toluene	0.24 mg/L
Ethyl Benzene	0.32 mg/L
Xylene	0.13 mg/L
1,1,1 Trichloroethane	0.24 mg/L
Trichloroethylene	0.03 mg/L
Tetrachloroethylene	0.01 mg/L

Any liquids containing concentrations equal to or greater than these criteria were sent to a licensed hazardous waste disposal facility.

Material Handling and Data Management

To ensure proper documentation of all materials leaving the site, the Ministry's waybill control system was strictly enforced. This applied to both liquid and solid materials. An inspector was present to ensure that a waybill was completed for each load leaving the site and to ensure that each load went to the correct disposal location.

The two nearest landfill disposal sites had daily quotas on the quantities of material that they would accept from this cleanup. The combined trucking and disposal costs to the more distant landfill were significantly higher, however, so it was essential to dispatch the trucks in the most cost efficient manner. For this purpose, a small computer was used to record all truck movements and to keep an up-to-date tally on the quantities of material sent to each destination. The computer was also used to keep track of quantities of

materials that were excavated and placed in temporary stockpiles before being removed from the site. Other functions of the computer included the preparation of daily and cumulative summaries of costs incurred and tabulation of the inventory of drums discovered. In addition, some of the results of the chemical analyses were tabulated on the computer.

Sampling Procedures

All liquid and solid samples collected for chemical analysis were placed in 250 mL glass bottles with a 1.5 cm opening. Bottles were fitted with a teflon septum and a plastic screw cap with the centre portion removed. All samples were delivered to the on-site laboratory within 2 hours or less.

Samples of liquid drum contents were obtained by means of syringes and tubing. Surface water samples from pits and streams were obtained by dipping the sample bottles and allowing them to fill to about half capacity before capping. Groundwater samples were obtained from piezometers by means of dedicated bailers constructed from copper pipe.

Near surface soil sampling included grab sampling and hand auger sampling. Grab samples of surface soils and newly excavated materials were taken using a small stainless steel spatula. A stainless steel hand auger was used to collect composite soil samples over an interval from 0.05 to 0.50 m below the surface. Deeper soil samples were obtained during the drilling program using a split tube sampler. These soil cores, approximately 4 cm in diameter by 0.5 m in length, were examined and logged immediately on the site and selected samples were taken for chemical analysis and for grain size analysis.

Sample Analysis

A total of 787 soil, water, and waste samples were analysed during the cleanup. Most of these samples were analysed on-site. The mobile laboratory was equipped with a gas liquid chromatograph with flame ionization and electron capture detectors. The analytical technique included heating the samples for at least one hour in a water bath at 85°C. A gaseous sample was extracted from the head space inside the sample bottle by penetrating the teflon septum using a hypodermic needle. The sample was injected into the gas chromatograph which was equipped with an integrator to speed up the production of analytical results.

A portion of the samples, including samples of raw waste, the split tube soil samples, and some replicate samples, were analysed at the Ministry's Rexdale laboratory to reduce the workload at the on-site laboratory and to provide a measure of quality assurance.

Geophysical Surveys

Geophysical surveys using Monenco's EM-31 electromagnetic induction instrument were carried out at the beginning of, during, and near the completion of the site cleanup. Conductivity readings with the instrument oriented in both north-south and east-west directions were recorded at points on the five metre grid in addition to walking continuous lines across the site. Each of the conductivity anomalies found during the surveys was excavated in a carefully controlled manner staged to minimize disturbance to the adjacent

materials. This approach prevented the spread of contamination and minimized the materials handling effort. Drums, typically buried individually or in groups of up to about 50, were found at depths from about 1 to 4 m. The drums were mostly ruptured and many were crushed almost flat, apparently during their burial. Few were found totally intact and still containing liquid wastes. The EM-31 was utilized regularly during excavation as part of the confirmatory process. A final survey was done near completion of the cleanup.

Cleanup Procedure

As each drum cache was discovered, individual drums were exposed, if necessary using hand tools, so as to minimize disturbance of the drums which were typically broken open. Great care was required at this point because it was necessary to work in the excavations. This work advanced slowly and methodically. Full protective clothing, including full face masks and respirators, was employed as required. Gas sniffers were used as excavations were entered and compressed air cylinders were kept available.

Drums containing liquids were carefully opened and pumpable liquid contents were transferred into secure drums for removal from the site. Soils adjacent to the drums were sniffed with an organic vapour detector and sampled, and the excavated drum and surrounding contaminated soil was removed to the steel lugger boxes. The operation then moved to the next drum. In all, 287 drums were removed from the site. Most were found crushed or otherwise not hydraulically sealed.

This approach to the cleanup, using sample analyses to direct the cleanup activities and to classify and segregate materials for appropriate disposal, required a rapid response from the on-site laboratory. In some cases, stockpiling of some materials was required to allow time for sample analyses.

As excavation proceeded to lower levels, pools of wastes and contaminated water were exposed. Hazardous fluids were pumped from the excavation by vacuum trucks and taken to a licensed facility for disposal.

During the removal of wastes and contaminated materials, a total of 386 samples of soil, water and waste were taken to distinguish between contaminated and uncontaminated materials and to determine where these materials were to be sent for disposal.

Cleanup Equipment

Most excavation and loading of trucks and lugger boxes was done by two track-mounted hydraulic backhoes with bucket capacities of approximately 1 m^3. The operation of each backhoe was closely directed by an experienced hydrogeologist or engineer who watched for the exposure of metal drums and waste and employed sensitive organic vapour sniffing equipment to assist in defining the level of contamination and hence the sampling and material handling requirements. A track-mounted front end loader was used for stockpiling materials requiring double handling, for occasional loading of trucks from the stockpile, and some site grading. A medium-sized bulldozer was used primarily for site and road grading. Other heavy vehicles used in the cleanup included vacuum tanker trucks and the truck and trailer used for handling and transporting the lugger boxes. All lugger boxes containing hazardous materials were securely covered before leaving the site.

All non-hazardous materials were removed from the site in tandem or triaxle dump trucks or tractor trailers with capacities varying from approximately 15 to 30 tonnes. The smaller trucks were used for hauling to the two nearby landfill sites (35 and 48 km) whereas the large tractor trailers were most cost effective for hauling to the more distant landfill disposal site (115 km).

Cleanup Quantities

A total of 12,960 tonnes (approximately 10,050 m^3) of non-hazardous wastes were removed from the site for disposal at certified sanitary landfill sites. Crushed drums and contaminated wastes and soils, totalling 194 m^3, were removed for disposal in 34 lugger boxes to a licenced hazardous waste disposal site near Sarnia, some 300 km from the cleanup site. During the cleanup operation a total of 287 metal drums were excavated and disposed of. About 25 of these were 5 gallon steel pails and the remainder were 30 and 45 gallon steel drums. A total of 11 secure drums, containing approximately 1 700 litres of hazardous liquid wastes were removed from the site. Additionally, 40 900 litres of bulk contaminated water and liquid waste were collected in vacuum tanker trucks from the pits and trenches.

Hydrogeological Investigation

The site lies in an area which is known physiographically as the Palgrave Moraine. This is an area of moderately sloping hilly topography in glacial drift deposits. According to previous studies (White, 1975), the glacial drift at the site is just over 100 m thick. It is comprised of an upper layer of Halton Till, which is underlain by ice contact stratified drift.

Monenco conducted a study of the ground water flow system and ground water quality at the site by drilling exploratory boreholes and installing a number of ground water observation wells (piezometers). A hollow stem auger drill was used to drill separate boreholes for each of 15 piezometers at eight sites. Piezometer screens were installed at different depths below the water table with one screen at each nest being near the water table to determine vertical hydraulic gradients and to allow for the collection of ground water samples from different depths.

The auger drilling to depths up to 26 m revealed a surficial soil composed of 3 to 6 m of silty loamy till which was highly fractured in some areas. The till is underlain by a stratified drift composed of layers of silt, fine sand and a few layers of clay and varved clay. Essentially all of the wastes had been buried in the near-surface till deposit.

The augers were carefully cleaned between each hole and were steam cleaned between sites. No lubricants were used on the augers or soil sampling tools. A total of 96 soil samples were taken for chemical analysis during the drilling program.

All but one of the piezometers were constructed of galvanized pipe and stainless steel screens. This was to avoid the possibility of organics leaching from the piezometer components into the ground water. The galvanized pipe and couplings were threaded and most had visible quantities of cutting oil present. Caution was taken to ensure that all piezometer components were cleaned of oil and any other organic contaminants by means of successive swabbing and brushing with dichloromethane and methanol both inside and outside.

The piezometers were installed with silica sand around the screens and bentonite plugs immediately above the screens and at intervals up the annulus of the drill hole. Lockable steel casings were grouted around the piezometers at the surface to protect them.

Dedicated copper bailers were suspended in each piezometer for obtaining ground water samples. A minimum of three times the volume of water standing in each piezometer was removed prior to each sampling. Monenco sampled each piezometer twice during the study and recommended a continued monitoring program for selected piezometers and the surface stream.

To evaluate the potential for leaching (or solving) of organic contaminants from plastic piezometer components, one piezometer made up of a PVC screen and threaded PVC pipe was installed nearby, and identical to, one of the metal piezometers near the creek at the east end of the site. The initial two samplings showed no significant differences in water quality in samples from the metal and the PVC piezometers.

Further details of the findings of the hydrogeological investigations are available in the Monenco Limited (1984) report.

Confirmatory Sampling

As the site cleanup progressed, a confirmatory sampling program was initiated. A total of 305 soil samples, including 21 replicates, were collected. Some of these were from the sides and base of completed excavations to ensure that clean soil had been reached. Others were from a 10 m square grid over the area of the site. All confirmatory sampling was done prior to regrading of the site to ensure that no areas of possible residual contamination were spread out or covered over.

In most cases, the confirmatory sampling showed that the remaining soil was clean, but in some instances, the soils failed to meet the clean criteria. In these areas, additional soil was removed and further confirmatory sampling was conducted until it was demonstrated that the remaining soil was clean.

SITE RESTORATION

The last load of waste was removed from the site on 5 December 1983, about two weeks ahead of the planned completion date. Due to the onset of winter weather conditions, the final grading and revegetation of the site was delayed until May 1984. To minimize the potential for soil erosion, the regraded slopes were kept as moderate as possible. As a check, two adjacent undisturbed slopes were surveyed. A comparison of the natural slopes with the steepest slopes in the regraded areas indicated that the slopes in the regraded areas are comparable to or flatter than nearby natural slopes. All areas of the site were graded to allow good drainage and to preserve the agricultural viability of the affected areas. The barren areas of the site were hydroseeded to approximate the native vegetation. The hydroseeding program was successful in establishing a suitable grass cover.

CONCLUSIONS

It was concluded at the end of the cleanup project that all solid and liquid wastes, contaminated soil, and sources of contamination had been removed from the site and properly disposed of in accordance with the criteria established by the Ministry. A very low concentration of trichlorethylene (0.02 mg/L) was found in one of the shallow piezometers near the creek at the east end of the site. This level was below the criteria established by the Ministry and is less than the tentative World Health Organization (1984) drinking water criteria. It is expected that this small quantity of slightly contaminated ground water will slowly discharge to the creek where its impact is expected to be negligible.

General Observations

Because of the emergency nature of this cleanup, Monenco and the Ministry agreed to a contract based on unit rates that were estimated from a preliminary assessment of the quantity and type of materials to be removed from the site. The tender documents indicated that there were some uncertainties about conditions at the site and that flexibility and negotiation may be required as the work proceeded. The cleanup progressed using a program of definitive sampling and analysis run concurrently with the removal of materials.

Although a number of problems developed during the program, the regular on-site negotiations between both parties aided in reaching rapid resolutions and the cleanup was completed ahead of schedule. Areas that were discussed and agreed to during the contract negotiations or the field work included:

- the combination of the initial two-stage cleanup approach so that both stages were performed concurrently, thus minimizing the amount of material rehandling required, improving cost effectiveness, and facilitating substantial completion prior to the onset of winter conditions;
- a review of a number of non-hazardous waste disposal sites and an agreement on the most acceptable and cost-effective combination of sites;
- a change in the basis of payment from volume unit rates to weight unit rates to improve the efficiency of cost control (the initially proposed landfill did not have a weight scale and charged by the truck load); and
- a renegotiation of unit rates based on the variation in quantities from those in the tender documents and the improved approach to material handling resulting from combining the two cleanup stages.

The success of this project demonstrated that, through close liaison and co-operation between the Ministry and an experienced cleanup contractor, the emergency cleanup was completed in an environmentally sound and cost efficient manner. It should be noted, however, that only a relatively small proportion of site cleanups are of an emergency nature such as this one. In other cases, more time may be available to fully assess site conditions and develop cleanup criteria and a detailed plan of remedial action using a logical sequence of steps. Also, and of great importance, older disposal areas would typically have a plume of soil and ground water contamination. In addition, in many cases, the areas of waste disposal at older sites would not be as obvious as they were at this site.

From experience gained during this project and a number of other industrial and hazardous waste site investigations, cleanups, and restorations, Monenco has developed a manual of guidelines for the step-wise approach to

decommissioning and cleaning up of industrial sites. The report will soon be published by Environment Canada. Monenco and Environment Canada will be putting on seminars (this fall in Ottawa/Hull and Calgary) to familiarize industry with these cleanup procedures. A limited quantity of advanced editions of the guidelines are available through Monenco.

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Gestion et traitement des sols et des eaux contaminés par les hydrocarbures polyaromatiques (HPA)

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RESUME

Le traitement du sol et de l'eau a fait l'objet de travaux dans le cas de contamination accidentelle par des hydrocarbures. Pour réaliser ces projets, de très nombreux tests ont été réalisés afin d'établir la méthode de gestion ou de traitement du sol et aussi le mode de traitement et de contrôle des contaminants présents dans l'eau. Il a été démontré que l'utilisation de l'ozone permettait au niveau du laboratoire puis au niveau de l'usine pilote de traitement, de contrôler la destruction des hydrocarbures polyaromatiques (HPA) potentiellement cancérigènes qui se trouvent présents dans l'eau et que la combustion fluidisée du sol pouvait permettre au traitement efficace. L'exposé présentera donc le volet traitement global sol/eau puis l'aspect destruction des HPA contenus dans l'eau et le sol.

1) INTRODUCTION

L'objectif des travaux de décontamination consiste à définir une méthode globale de traitement sol/eau devant être appliquée au cas d'un déversement accidentel d'un réservoir d'hydrocarbures ou d'eaux contaminées contenant des HPA. Ces derniers se trouvent généralement présents dans les résidus des usines à gaz. Le problème consiste à traiter des hydrocarbures légers, de goudrons et d'hydrocarbures très lourds du type asphaltène ainsi que des eaux fortement chargées en hydrocarbures dissous. La présence de produits potentiellement cancérigènes présente de plus l'application de solutions de traitement particulières. L'infiltration dans le sol de type silto sableuse et silto argileuse de ces liquides conduisit à la formation de poches d'hydrocarbures souterraines (ou fosses) et à une dispersion massive à la surface et dans les eaux des nappes phréatiques.

2) METHODOLOGIE DE GESTION DU SOL

La méthodologie de gestion de ces sols requiert au préalable la détermination de l'étendue de la décontamination et la connaissance de l'hydrogéologie locale du site contaminé. Une fois ces tâches accomplies, il est possible de:

* déterminer une aire de travail sur la surface contaminée;

* trier les pièces volumineuses enfouies dans le sol contaminé (tuyauterie des anciens réservoirs, morceaux de béton, etc...);

* trier et de transporter sur l'aire de travail le sol contaminé situé à la périphérie de ses limites;

* retourner et d'assécher le sol contaminé par couches de 10 cm, afin de stabiliser et d'oxyder partiellement les hydrocarbures présents;

* constituer des tas de sol stabilisé à la périphérie de l'aire de travail;

* transporter, d'enfouir et de compacter le sol stabilisé dans 3 bassins spécialement conçus à cet effet.

Les bassins d'enfouissement ou de rétention, pour le sol remanié, sont généralement prévus à proximité du site. Le fond et la surface de ces bassins doivent être étanches et des tests de compatibilité des membranes synthétiques avec les hydrocarbures présents sur le terrain doivent être effectués. Des échantillons de membranes renforcées ou non en PCV, CPE, HDPE, HRPA, etc. peuvent être analysés ou testés et, finalement, la sélection du type de membrane peut être arrêtée. Actuellement pour des raisons techniques et économiques les membranes HDPE trouvent un champ d'application intéressant.

Par souci de compatibilité avec les plus récentes normes de l'EPA (Environmental Protection Agency) aux Etats-Unis, deux couches d'argile imperméable doivent être recommandées afin d'emprisonner entre elles la membrane synthétique de fond en HDPE. Les bassins possèdent donc une triple protection grâce à ces trois couches de matériaux naturels et synthétiques. Les plus récentes normes américaines font apparaître la nécessité de la double couverture avec des drains intermédiaires pour le contrôle des fuites d'eau. Afin de ne pas accumuler les eaux de pluie dans les bassins, la surface de ces derniers est scellée avec la même membrane synthétique et une couche de terre arable recouvre ensuite cette dernière barrière protectrice. Un réseau de drainage des eaux du fond des bassins et des gaz est prévu, ainsi qu'un puits d'observation central. En parallèle à l'étude intensive faite sur le sol contaminé, une étude hydrogéologique est entreprise sur le terrain. Des piézomètres permettent de connaître les conditions hydrogéologiques du site et le degré de contamination des eaux souterraines.

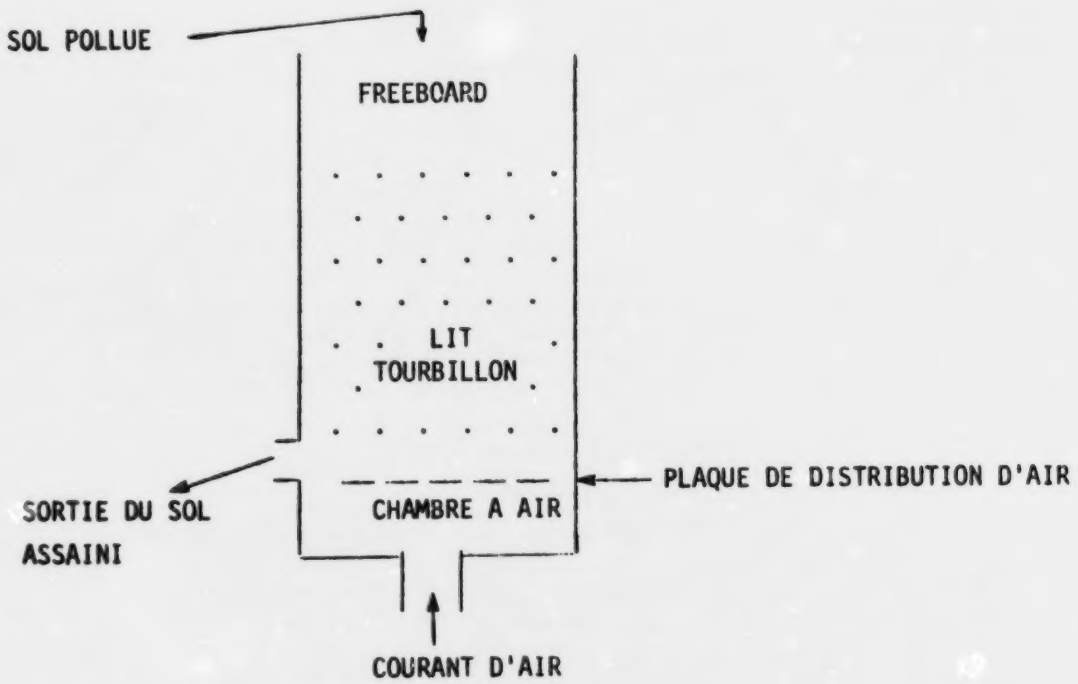
3) MÉTHODOLOGIE DE TRAITEMENT DU SOL

Une autre alternative à l'enfouissement consiste à la combustion dans un lit tourbillon du sol contaminé. Il s'agit plus particulièrement de contaminants du type cyanures et hydrocarbures aromatiques polycycliques toxiques qui peuvent être traités de façon efficace grâce à ce procédé. En outre, des émulsions, de l'huile usée, des déchets domestiques et d'autres matières toxiques peuvent être brûlés dans ce lit tourbillon. La société ESDEX a réussi récemment avec cette technique à traiter efficacement divers polluants comme les hydrocarbures polyaromatiques et la description des résultats est donnée ci-après.

Le four à lit tourbillon comprend deux compartiments: la partie inférieure, que nous appelons une chambre à air et une partie supérieure - le lit tourbillon avec ensuite un espace à combustion, ou un système de flambage ("freeboard"). Toute la partie supérieure est faite en briques réfractaires. Les deux compartiments sont séparés par une plaque de distribution d'air (dans laquelle se trouvent des buses d'air) qui distribue l'air de combustion uniformément à travers toute la surface du lit. Lorsqu'on met en marche le ventilateur, les dimensions du lit augmentent de 20 à 30%. Le lit consiste en un mélange de combustibles et de sol.

Le lit est porté à une température de 800 à 1 000°C de façon à avoir une combustion totale du sol qu'on y introduit. Grâce à ce mélange intensif de suffisamment d'oxygène avec l'air chaud, toute particule de sol polluë sera brûlée entièrement.

Les gaz de combustion vont du lit expansé dans le système de flambage ("freeboard"). Les gaz d'échappement qui contiennent possiblement encore des polluants demeurent assez longtemps dans cet espace pour avoir une combustion complète (même des particules légères qui pourraient rester dans le courant d'air).

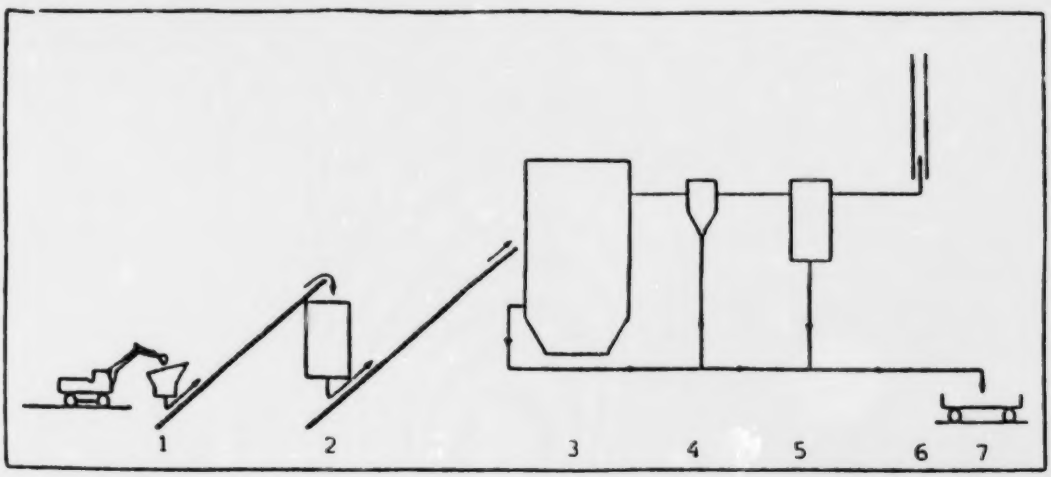


PRINCIPE DE BASE DE LA TECHNIQUE DU LIT TOURBILLON

Grâce à des additifs comme la chaux, il est possible de neutraliser certaines particules du sol ou du combustible comme le chlore et le souffre et de les incorporer au sol.

Les gaz qui sortent, contiennent encore de la poussière fine et grosse. Dans le cyclone les grosses particules solides sont séparées du courant de gaz. Ensuite le gaz est conduit vers un filtre à poussière. La poussière fine du courant de gaz est retenue par le filtre à poussière, et ensuite elle est mise dans un collecteur. La poussière qui reste dans les gaz d'échappement

LE FOUR À LIT TOURBILLON



1. Système d'alimentation
2. Système de dosage
3. Four à lit tourbillon
4. Cyclone
5. Filtre à poussière
6. Cheminée
7. Sortie du sol assaini

qui s'échappent par la cheminée demeure dans les limites des valeurs d'émission.

Le sol assaini qui sort de l'installation a obtenu - grâce aux conditions de combustion optimales - une couleur semblable au sable des dunes (ou du sable inerte).

En novembre 1984 des essais ont commencé avec ce four en utilisant le sol provenant d'un terrain d'une ancienne usine à gaz à Haarlem. Lors de ces essais, les valeurs d'émission ont été mesurées par une unité mobile à certains jours avec des paramètres différents. Ces essais forment une partie d'une série d'essais avec plusieurs types de sol avec un degré de pollution assez varié.

Après chaque série d'essais, des échantillons qui ont été analysés, entre autres, afin de déterminer l'efficacité du procédé dans des conditions existantes.

RÉSULTATS DES ESSAIS

Sol

Les essais ont démontré que le sol de diverses compositions, comme le sable avec de la tourbe, de l'argile, de la glaise ou de la vase, peut être traité par l'installation.

Les résultats des analyses qui ont été faites du sol avant et après le traitement démontrent que la technique d'assainissement permet de traiter le sol avec une combinaison de polluants. Le tableau suivant donne un aperçu du résultat de deux cas: un où il y avait une grande quantité d'hydrocarbures aromatiques polycycliques (HAP) avec un total de 3 735 ppm en combinaison avec une quantité raisonnable de cyanures (475 ppm); l'autre essai concernait du sol principalement pollué par une très grande quantité de cyanures (4 120 ppm).

Dans les deux cas, le degré d'assainissement obtenu est:

- CN^- total	2 ppm	(objectif: 5 ppm)
- HAP	<0,1 ppm	(objectif: 0,1 ppm)

Il n'y a que le sol qui sort du four sous forme de sable inerte.

Emissions:

Des mesures d'émission ont été enregistrées lors d'un de ces essais dont voici les résultats.

360 kg de sol fut traité par heure avec un état d'analyse semblable à celui au **Tableau 1**, série II08.

Le débit du gaz de combustion était de 940 m^3/h; l'oxygène dans les gaz d'échappement était de 7,1%; le CO_2 était de 13% et le CO de 0,003%.

	SO_2	NO_x	C_xH_y	CN tot.	HAP	poussière
mg/m^3	1 168	12,7	1,44	0,12	$0,43 \times 10^{-3}$	290
kg/h°	1,1	0,01	0,001	0,0001	$0,4 \times 10^{-6}$	0,27

La quantité de SO_2 peut être réduite davantage en ajoutant de la chaux au lit. Les concentrations de poussière dans les gaz d'échappement peuvent être baissées à moins de 50 mg/m^3 lorsqu'on utilise un autre filtre que celui que nous avions essayé.

Ces données laissaient prévoir une alimentation de 16 m^3/h (100 000 gal/jour) dans le réseau de drainage à la périphérie de l'aire de travail du site contaminé. En raison du degré élevé de contamination, dû principalement au contenu en hydrocarbures dissous ou en suspension, les eaux durent être traitées avant

Tableau 1 : aperçu des resultats des essais

Date des essais : les 19 et 20 novembre 1984
Méthode de l'analyse : extraction-«GLC»-titration
Codes des échantillons : II08 et II10

	II08		II10	
composants	matériau de base (ppm)	terre assainie (ppm)	matériau de base (ppm)	terre assainie (ppm)
CN^- total	475	0,5	4 120	2
Naphtalène	90	0,1	15	0,1
Acenaphtène	15	<0,1	5	<0,1
Dibenzofurane	110	<0,1	55	<0,1
Fluorène	170	<0,1	65	<0,1
Phénanthrène	470	<0,1	170	<0,1
Anthracène	360	<0,1	90	<0,1
Fluoranthène	550	<0,1	150	<0,1
Pyrène	390	<0,1	95	<0,1
1,2 Benzanthracène	470	<0,1	100	<0,1
Chrysène	190	<0,1	75	<0,1
Benzo(b+j+k)fluoranthène	370	<0,1	70	<0,1
1,2-Benzopyrène	150	<0,1	40	<0,1
3,4-Benzopyrène	160	<0,1	45	<0,1
Indeno(1,2,3,cd)pyrène	120	<0,1	35	<0,1
1,12-benzopérylène	120	<0,1	35	<0,1

La limite de détection pour tous les composants est de 0,1 ppm.

leur rejet dans l'environnement. La présence de substances cancérigènes (certains hydrocarbures polyaromatiques) entraîna de nombreux essais permettant de maîtriser la technique de destruction de ces substances par l'ozone.

Sur l'aire de traitement du sol contaminé, le fossé ceinturant le site fut aménagé afin de recueillir les eaux de pluie et de drainage, de contrôler la technique de retournement et d'assèchement du sol contaminé et de permettre le déplacement de la machinerie lourde. Une fois pompées, ces eaux furent alors traitées dans l'unité mobile d'ozonisation, d'une capacité nominale de 16 m^3/heure.

L'unité de traitement des eaux a été construite sur 4 remorques de 13,5 m de longueur. Elle a été conçue de façon à traiter l'eau contaminée en continu et en deux étapes de traitement distinctes.

Le traitement primaire consiste à séparer, par gravité, les particules en suspension provenant du fossé de drainage puis d'écumer les huiles dans un séparateur analogue à un API. Les eaux passent ensuite dans un sédimenteur dans lequel un agent floculant (alun) précipite les particules solides qui n'auraient pas été captées au début. A la sortie du sédimenteur, les eaux prépurées sont acheminées vers le traitement secondaire.

Le traitement secondaire consiste essentiellement à oxyder les hydrocarbures résiduels par ozone. Pour ce faire, les eaux sortant du sédimenteur sont recirculées dans une colonne de contact à garnissages où l'air chargé d'ozone monte à contre-courant de l'eau afin d'établir le transfert de l'ozone dans l'eau. L'eau ozonisée est finalement stabilisée dans un réservoir puis passée dans un filtre à sable avant d'être rejetée dans le réseau d'égout.

4) MÉTHODOLOGIE DE TRAITEMENT DES EAUX

En raison du degré élevé de contamination, dû principalement au contenu en hydrocarbures dissous ou en suspension, les eaux doivent être traitées avant leur rejet dans l'environnement. La présence de substances potentiellement cancérigènes (certains hydrocarbures polyaromatiques) nécessita de maîtriser la technique de destruction de ces substances.

Sur l'aire de traitement du sol contaminé, un fossé ceinturant le site doit être aménagé afin de recueillir les eaux de pluie et de drainage, de contrôler la technique de retournement et d'assèchement du sol contaminé et de permettre le déplacement de la machinerie lourde. Une fois pompées, ces eaux doivent être alors traitées.

Le traitement consiste à séparer, par gravité, les particules en suspension provenant du fossé de drainage puis d'écumer les

huiles dans un séparateur analogue à un API. Les eaux passent ensuite dans un sédimenteur dans lequel un agent floculant (alun) précipite les particules solides qui n'auraient pas été captées au début. Un contrôle rigoureux du pH dans les eaux à traiter permet une excellente séparation de portion des solides et des sels ferreux toujours présents.

La suite du traitement consiste essentiellement à oxyder les hydrocarbures résiduels par ozone. Pour ce faire, les eaux sortant du sédimenteur sont recirculées dans une colonne de contact à garnissages où l'air chargé d'ozone monte à contre-courant de l'eau afin d'établir le transfert de l'ozone dans l'eau. Trois séries de tests ont été réalisés afin de s'assurer de l'efficacité du traitement par l'ozone. Un ozonateur de laboratoire produisant 1.3 g O_3/hr a été utilisé. Le mélange O_2/O_3 est mis ensuite en contact avec 500 ml d'eau provenant du sol contaminé durant des périodes variant de 5 à 30 minutes. Les résultats obtenus sont présentés au **Tableau 2.** A l'exception d'un échantillon, la destination des HPA cancérigènes est de 100%. Pour les autres types de HPA, leur destruction varie de 70 à 95%. Pour ces essais, les différents HPA présents étaient les suivants:

Non cancérigènes	Cancérigènes
Naphtalène	Benzo(a)anthracène
Acénaphtalène	Chryzène
Acénaphthène	Benzo(b)fluoranthène
Fluorène	Benzo(K)fluoranthène
Phénanthrène	Benzo(a)pyrène
Anthracène	Dibenzo(a,h)anthracène
Fluoranthène	Benzo (g,h,i)pérylène
Pyrène	Indeno(1,2,3,c,d)pyrène

Basée sur ces expériences, une unité mobile d'ozonisation ayant une capacité de 52 kg O_3/hr a été construite et installée à la suite des unités primaires également mobiles de déssablage, déhuilage et de floculation/sédimentation. La représentation de cette unité est fournie à la Figure 6 suivante. Les résultats furent les suivants amenés à une moyenne de 17 semaines d'opération.

Moyenne des concentrations

	Avant traitement	Après traitement	Efficacité de traitement
HPA totaux	0.143 mg/l	0.041 mg/l	69%
HPA cancérigènes	0.045 mg/l	0.0047 mg/l	90%

TABLEAU 2 DESTRUCTION DES HPA PAR OZONISATION

Essais		CONCENTRATION DES HPA (ppb)				% DESTRUCTION HPA non cancérigènes	% DESTRUCTION HPA cancérigènes
		HPA non cancérigènes (ppb)		HPA cancérigènes (ppb)			
		Avant ozonisation	Après ozonisation	Avant ozonisation	Après Ozonisation		
1	a	1 956	301	96	0	85	100
	b	1 781	493	80	0	72	100
	c	1 521	215	42	0	86	100
	d	1 697	179	137	0	89	100
	e	707	87	7	0	88	100
2	a	22 134	1 667	861	0	92	100
	b	14 224	1 413	5	0	90	100
	c	17 254	826	249	47	95	81
	d	7 173	914	42	0	87	100
	e	25 998	1 442	48	0	94	100
3	a	80 744	24 037	0	0	70	0
	b	13 917	1 295	66	0	91	100
	c	14 307	1 564	33	0	89	100
	d	29 357	2 429	438	0	92	100
	e	17 136	1 561	0	0	91	0

A titre indicatif, l'efficacité rapportée aux huiles et graisses a été de 88% et aux composés phénolés de 75%.

L'analyse a porté sur l'identification de 4 HPA par chromatographie liquide à haute performance (HPLC); l'anthracène, le fluoranthène, le benzo(g,h,i)périylène et le benzo(a)pyrène.
L'analyse a donc porté sur 2 produits non cancérigènes et 2 produits classés cancérigènes dont le benzo(a)pyrène qui se trouve être le deuxième plus cancérigène des HPA cotés par l'indice d'Iball.

5) CONCLUSION

La gestion actuelle des sols contaminés par des produits organiques, des huiles et graisses ou des hydrocarbures polyaromatique HPA fait intervenir plusieurs notions comme l'enfouissement sécuritaire et contrôlé à l'aide de barrière naturelle et de membranes synthétiques. Le traitement en tant que tel devient réalisable pour autant que la combustion contrôlée du sol soit réalisée et que l'ozonation des eaux puisse assurer la qualité des rejets dans l'environnement. Ces nouvelles technologies sont utilisées à l'échelle pilote et semi industrielle pour contrôler la qualité de l'environnement et ont révélé leur efficacité dans le traitement des sols contaminés des anciennes usines de cokéfaction et de production de gaz.

Annexe 1

NOTIONS SUR LES HYDROCARBURES POLYAROMATIQUES (HPA)

Les notions de base correspondant à la caractérisation et à l'analyse spécifiques des HPA ont été développées par le Dr. Hugues Ménard, Dépt. de chimie, Université de Sherbrooke. Ces notions sont tout d'abord présentées ci-après:

Plusieurs de ces produits potentiellement cancérigènes possèdent plus de trois cycles benzéniques. De ce groupe, certains sont plus carcinogènes que d'autres, par exemple le benzo(a)pyrène, B(a)P le 7, 12-diméthylbenz(a)anthracène et le 3-méthylcholanthrène.

Plusieurs de ces HAP sont largement répandus dans l'environnement car ils sont formés à partir d'une combustion incomplète i.e., la pyrolyse de matières organiques et principalement du carburant (spécialement le charbon)*. Le B(a)P est parmi l'une des substances très cancérigènes et très abondantes que l'on retrouve dans l'air, l'eau, la nourriture et dans la cigarette.

La **Figure 1**, ci-dessous, nous représente les unités de base des HAP numérotés selon la nomenclature de IUPAC et de Richter.

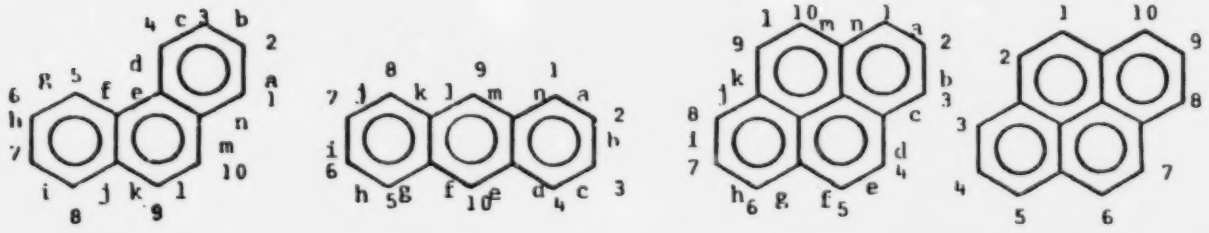


FIGURE 1 Représentation des unités de base des HAP selon Woo et Arcos

La **Figure 2**, nous donne la numérotation sous les deux formes différentes du B(a)P et du Benz(a)anthracène. La nomenclature de ces HAP est expliquée très clairement dans cette publication de Woo et Arcos (1981).

* le cas du traitement envisagé s'adresse spécifiquement à une cokerie.

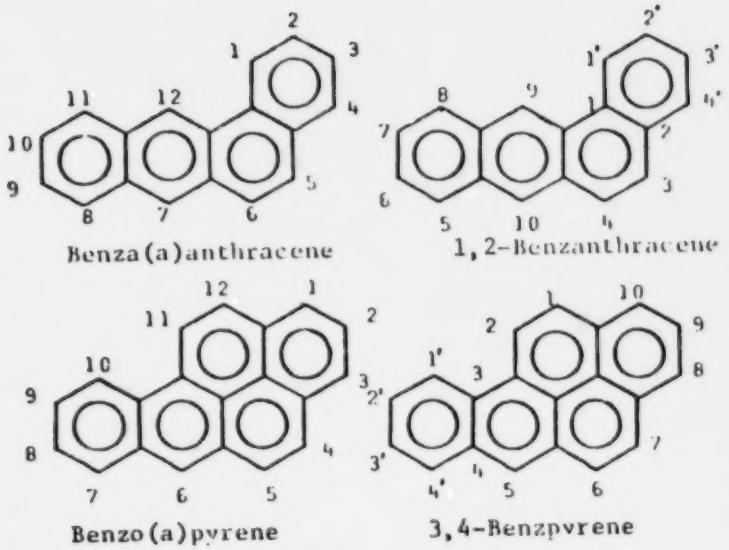


FIGURE 2 Numérotation du B(a)P et Benz(a)anthracène selon IUPAC et Richter. D'après Woo et Arcos.

Plusieurs de ces HAP sont faiblement solubles dans l'eau et même parfois totalement insolubles. Par exemple, on peut noter que la solubilité du B(a)P dans l'eau se situe aux alentours de 10^{-8} à 10^{-7} mol/li. Cependant, un surfactant peut substantiellement augmenter la solubilité du B(a)P par formation de micelles. Plusieurs solvants organiques tels que le benzène, l'acétone, l'hexane et le tétrahydrofurane peuvent dissoudre ces HAP.

Tous les HAP ont une forte tendance à s'adsorber sur les poussières. Ces particules viennent donc jouer un rôle essentiel lors de la mise en contact avec la peau et les tissus pulmonaires. Plusieurs de ces HAP sont sensibles en UV et photosensibles. Ils peuvent former des endoperoxydes lorsqu'ils subissent un clivage ou une désalkylation. L'ozone réagit facilement avec les HAP pour donner des sous-produits oxydés. Comme ces HAP s'adsorbent facilement sur les particules et sont photosensibles, ils deviennent donc biodégradables avec le temps.

La potentialité d'une substance à être cancérigène se reflète par deux paramètres, l'indice d'Iball et la courbe de la relation dose-réponse. L'indice Iball est défini comme étant le rapport de tumeurs incidentes (% animaux avec une tumeur) sur une période de temps (nombre de jours à partir de l'injection) le tout multiplié par 100.

$$\text{Indice Iball} = \frac{\% \text{ qui ont une tumeur}}{\text{nombre de jours}} \quad 100$$

D'un autre côté, la courbe dose-réponse peut démontrer la relation qu'il y a entre les tumeurs incidentes et la dose administrée. On note que lors de l'inhalation de B(a)P, s'il y a présence d'irritants (ex.: dioxide de soufre), la réponse sera plus rapide.

Par exemple, la dose journalière mortelle avec le temps pour une souris en présence d'un irritant, tel que le SO_2, sera de 1,4 µg de B(a)P par litre d'air et ce, jusqu'à concurrence de 10 µg/li., 1 heure par jour.

De Woo et Arcos (1981), nous avons repris la figure de certains dérivés de la famille des HAP. On notera que l'astérisque sur certains produits représente un certain potentiel carcinogène. De cette **Figure 3**, nous avons retiré certains résultats de l'indice Iball représenté au **Tableau 3.**

Les produits cancérigènes des HAP sont essentiellement des molécules planaires. Les HAP qui sont non substitués et qui n'ont seulement que 3 cycles sont inactifs. Par contre, ceux qui ont plus de 6 cycles peuvent être fortement carcinogènes. Ce qui peut dénoter une certaine corrélation entre le poids moléculaire et le pouvoir carcinogène. L'état cancérisme le plus actif se retrouve pour les molécules occupant une aire de surface se situant entre 100 et 140 A et le pic de l'activité maximale se situant à 120 A^2. (Arcos et Argus 1974).

Pulman et Pulman (1955) ont postulé une théorie électronique de la cancérologie chimique, la théorie de la région K et L. Cependant, cette théorie n'a pas été retenue car après vérification, la région K ne semblait pas être prédominante. Peu après, c'est la région de la "baie" qui a été retenue comme le démontre la **Figure 4.** C'est dire que la région de la "baie" est

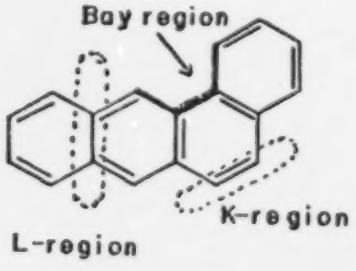


FIGURE 4 Théorie de la région de la "baie"

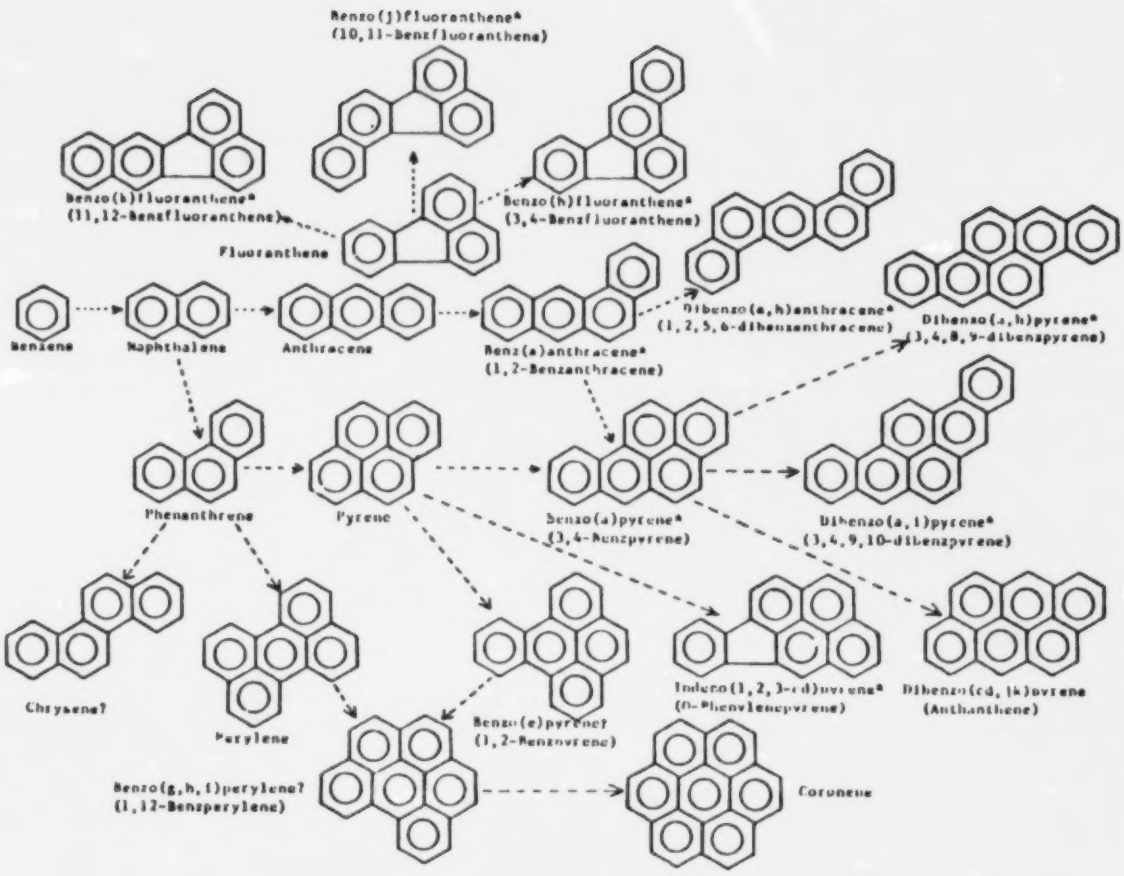


Figure 3. Les dérivés de la famille des HAP. D'après Woo et Arcos (1981).

Tableau 3. Indice du potentiel cancérogène des HAP. D'après Woo et Arcos (1981).

Produit	Indice Jhall
dibenzo(a,i)pyrène	78
benzo(a)pyrène	72
benzo(b)fluoranthène	68
dibenzo(a,h)pyrène	60
benzo(j)fluoranthène	59
dibenz(a,h)anthracène	25
dibenzo(cd,jk)pyrène	21
ideno(1,2,3-cd)pyrène	16
benzo(k)fluoranthène	15
benz(a)anthracène	5
benzo(e)pyrène	2
chryzène	1
benzo(g,h,i)perylène	marginal
anthracène	0
benzène	0
coronène	0
fluoranthène	0
naphtalène	0
pérylène	0
phénanthrène	0
pyrène	0

maintenant considérée comme site moléculaire critique. Utilisant le B(a)P comme composé modèle, plusieurs groupes de chercheurs en sont arrivés à la même conclusion que le 7,8-dihydrodiol-9, 10-oxyde de B(a)P. Une substitution du cycle hydrogène des HAP par des groupements tels que: alkyle, hydroxyle et halogène peuvent ainsi nous donner des produits qui ont un potentiel cancérigène supérieur ou inférieur, dépendamment de la nature du groupement de substitution et de sa position.

De récentes études ont accru la théorie de la région de la "baie", vu que des groupements époxide dihydrodiol de différents HAP non substitués peuvent être des plus cancérigènes. On en est arrivé à la conclusion que le 7,8-dihydrodiol-9,10-oxyde de B(a)P était le dérivé le plus carcinogène du B(a)P. (Lehr et Jerina (1977)). Cette région de l'époxyde diol du B(a)P sont plus cancérigènes et mutagéniques que les composés parents. Ce sont deux diastéréocoisomères qui jouent les rôles les plus significatifs **in vivo** en initiant les tumeurs induites ou interagissent avec les macromolécules cellulaires.

Il est évident que la région de la baie des époxydes des HAP nous donnent certains produits qui sont reconnus comme étant parmi les plus cancérigènes. De ceux-ci nous pouvons mentionner le 3,4-dihydrodiol-1, 2-oxyde de benz(a)anthracène; le 1,2-dihydrodiol-3,4-oxide de chrysène et le 7,8-dihydrodiol-9,10-oxyde de B(a)P (vu en **Figure 5**).

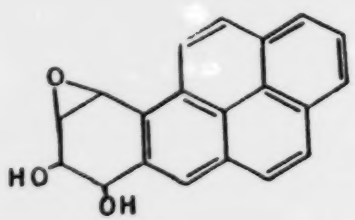
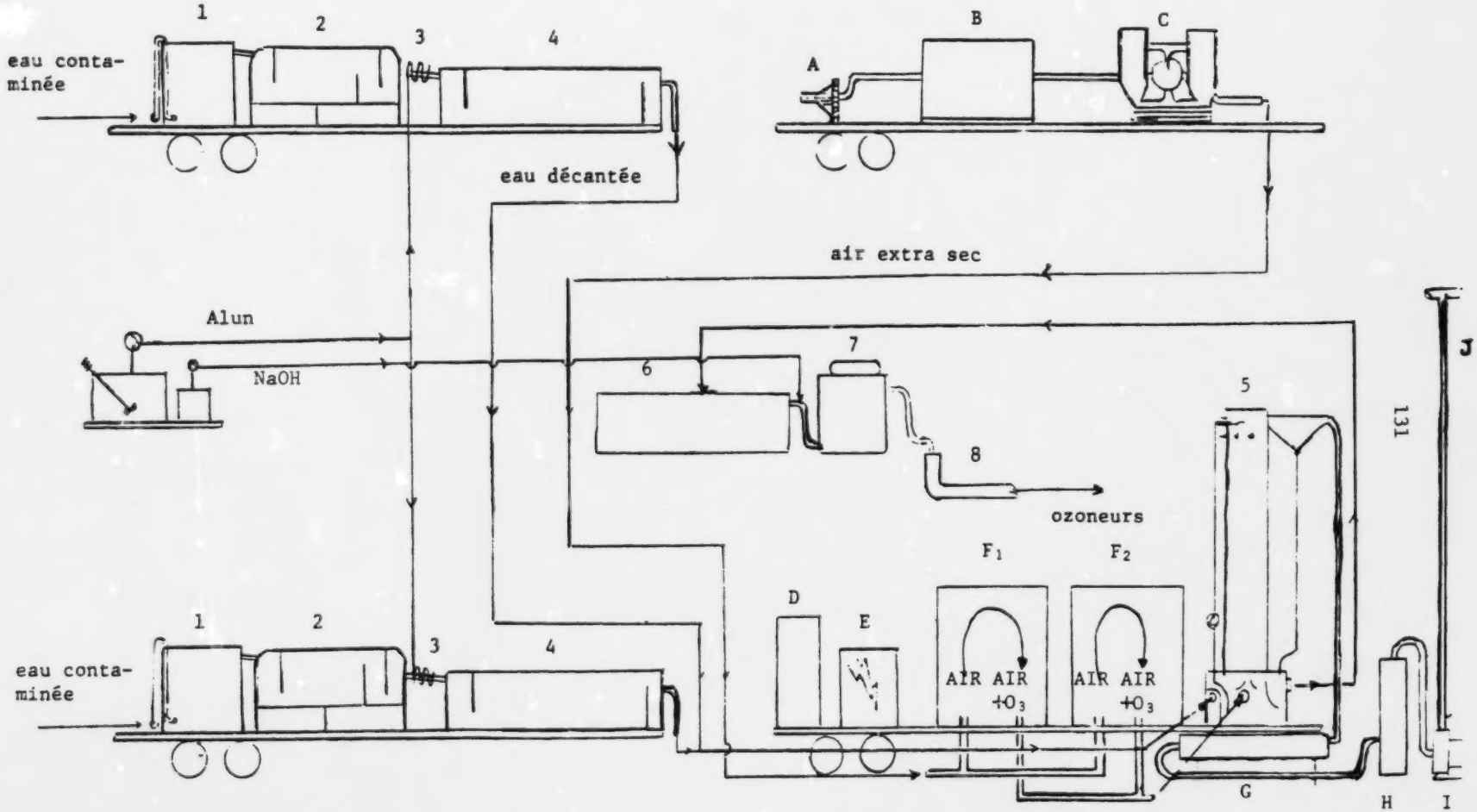


FIGURE 5 7,8-dihydrodiol-9,10-oxyde de B(a)P, d'après Woo et Arcos (1981).

Annexe 2

- Schématisation de l'unité de traitement des eaux
- Installation d'essai de combustion de sol

FIGURE 6 SCHEMATISATION DE L'UNITE MOBILE DE TRAITEMENT DES EAUX



1: dessableur, 2: séparateur d'huile, 3: mélangeur en ligne, 4: sédimenteur, 5: tour de contact, 6: bassin de réaction, 7: filtre à sable, 8: conduit d'évacuation sous-terrain
A: ventilateur, B: unité de réfrigération, C: dessicateur à sel de silice, D: panneau de contrôle, E: transformateur, F_1- F_2: ozonisateurs, G: Destructeur d'ozone, H: échangeur de chaleur, I: ventilateur, J: conduit d'évacuation

ESDEX V.O.F.

Installation d'essai

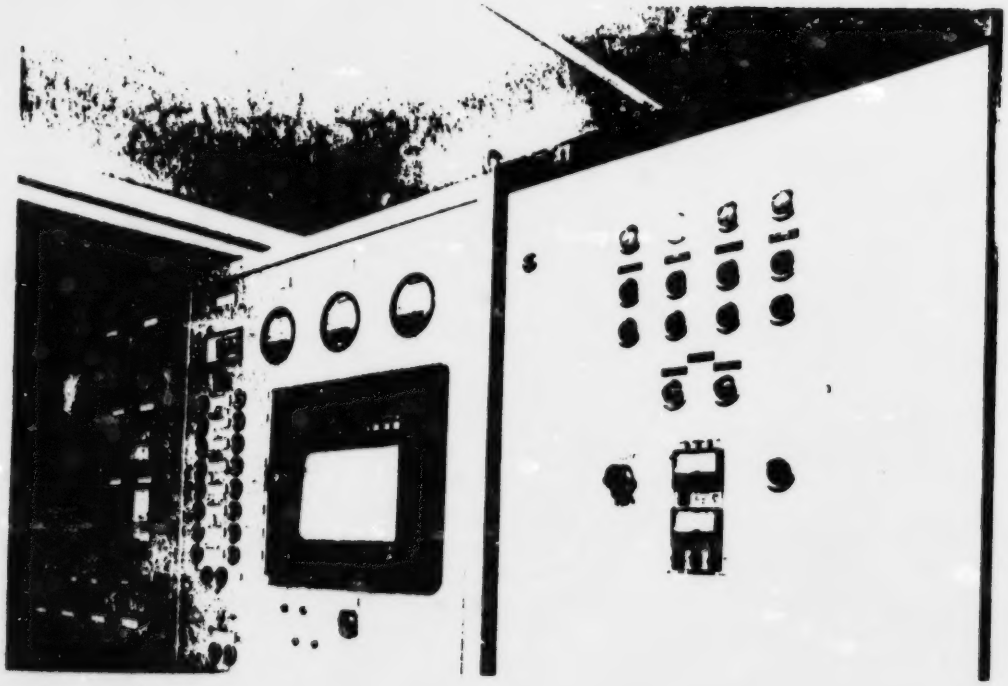


Tableau de l'installation d'essai

USES AND PITFALLS OF STATISTICAL DISCRIMINATION TECHNIQUES IN ASSESSMENT OF REMEDIATION EFFECTIVENESS AT LANDFILLS

by

Edward A. McBean (1) and Frank A. Rovers (2)

INTRODUCTION

An important element of an environmental impact assessment involves determining whether groundwater is improving or deteriorating over space and/or time. The combined effects of concerns such as uncertainties in sampling and laboratory analyses, and the vagaries of nature, require that such assessments involve use of statistical significance tests. The utility of the statistical significance tests is, however, constrained by limiting assumptions implicit in the tests. Considerations such as natural variability in groundwater transport, errors in sampling methodologies, and the brevity of the available data also introduce difficulties in the use of the statistical tests.

On the positive side, an important result of statistical significance testing of groundwater quality data is that the probability of an erroneous conclusion can be quantified. This makes it possible to evaluate the quality of the evidence provided by the test outcome in terms of the likelihood that it reflects reality. For example, in the

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RCRA regulations as used in hazardous waste management assessments in the U.S. (Federal Register, 1982), the statistical evidence is the primary evidence considered before deciding that the facility may be impacting the groundwater quality. A false positive (Type I error) in the significance test may, therefore, result in a facility operator needlessly carrying out difficult and expensive remedial actions. Conversely, the consequences of failure to detect actual groundwater contamination (i.e. a false negative or Type II error) could be extremely costly and potentially harmful to human health.

THE ARRAY OF ALTERNATIVES

In response to the discrimination problem, a number of discrimination testing procedures have been proposed. No absolute rules are available for selecting the discrimination procedures to use in a specific application, only guidelines. To a large extent, the selection of the best procedure involves careful scrutiny of the characteristics of the problem-at-hand and the assumptions implicit in the particular discrimination technique being considered.

All of the techniques involve a similar premise: the statement of a null hypothesis, for example, such that for any particular chemical, the initial background mean and the mean in the particular well being examined are equal. The alternative hypothesis for all parameters (except pH) is the upper-tailed hypothesis that the monitored mean is greater than the initial background mean. When a result is obtained which is very unlikely to have arisen by chance, the result is said to be statistically significant; it is difficult to ascribe the findings to chance, and the difference must in all common sense, be accepted as a real difference.

The general procedure of significance testing consists of:

(i) formulating a suitable (in terms of the problem context) null hypothesis (e.g. there is no difference between the two sample means);

(ii) calculating the appropriate test statistic;

(iii) defining the acceptance/rejection region; and,

(iv) drawing a conclusion based on whether the calculated test statistic is in the acceptance or rejection regions (e.g. if the null hypothesis is rejected, than there is a significant difference between the two sample means. Note that if the result proves non-significant, it is equivalent to a verdict of "not proven" — there is still the opportunity to consider further data which may become available. The size of the sample upon which the hypothesis test is to be made is important — a small sample is likely to produce a rejection of the null hypothesis only if the null hypothesis is very wrong).

As indicated by the preceding, the quantification by statistical analysis in general, and hypothesis testing in particular, is intended to reduce and summarize observed data, to present information precisely and meaningfully, and to determine some of the underlying characteristics of the observed phenomena. It should not be presumed that current knowledge of statistical analysis is always sufficient to provide answers to many of the complex problems of groundwater contamination. The complexities result from numerous phenomena, including: (i) the effect of limited data; (ii) natural variability; (iii) laboratory and sampling errors; and (iv) the limitations of the mathematical technique(s) used in the analysis.

As (iv) above indicates, the capabilities of the available analysis techniques, a number of which exist, may be an important concern in assessment. Each of the alternative techniques imply assumptions that must be recognized to avoid incorrect conclusions arising from inappropriate applications.

The majority of statistical discrimination tests that have been employed in groundwater problems for testing the difference between the means may be summarized as either of the parametric type, or the non-parametric type. The most commonly-used examples of each type are provided in Table 1. The differentiation between the parametric techniques and the non-parametric techniques arises in that the former employ the data as determined from the sampling programme, whereas the non-parametric techniques involve replacement of the original ranked-in-accord-with-magnitude data, with their ranks. The subsequent testing in the non-parametric tests is then done using only the ranks, which indicates why the non-parametric techniques tend to lose their discrimination power: what previously was potentially unequally-spaced data (and therefore, information about the concentrations) is replaced by equally-spaced data (the ranks).

An indication of the mathematical basis for the parametric techniques is provided in Table 2. Some comments relative to each of the procedures follow:

(i) the two sample t-test is a powerful discrimination tool but the stringency of the assumptions implicit in the test make its use difficult in environmental engineering problems. For example, the impact of an effective remedial measure on groundwater quality will adjust both the mean value of concentration and the variance of the concentrations;

(ii) Approximations to the t-test lose some discrimination capability in detecting changes. As a specific example, Cochran's Approximation uses (n-1) and (m-1) degrees of freedom; (m+n-2) as used in the t-test must always be larger than either (n-1) or (m-1). The failure of the test to reflect this approximation is to cause the actual level of significance of the test to be higher than the presumed value (e.g. 0.05). For further details see McBean and Rovers (1985);

(iii) Data transformation approaches have a degree of arbitrariness with respect to the transformation to be employed for a specific application;

(iv) The Paired t-test is used when the sample populations are not independent, as occur for example in monitoring upstream and downstream of a contaminant source. This differencing approach is particularly important for data series possessing seasonality — a part of the variance is recurring and yet, if not removed, implies the variance is very substantial and thus would mask potentially significant changes. Therefore, although the paired test has one-half the degrees of freedom of the two-sample t-test, the paired test does not "see" the cyclical variation which effects both populations, and thus does not include it in the calculation of the standard error.

CASE STUDY EXAMPLE

In the space available, only limited indications of the advantages/disadvantages of the alternative discrimination techniques are possible. Therefore, simply as an example of the tradeoffs needed

in some circumstances consider the situation when data contain seasonal variability, in addition to random sampling and analytical errors. In this circumstance, the ability to establish whether a statistically significant impact has occurred, is made more difficult. This difficulty arises because now there is a variance associated with the seasonal variability in addition to the other sources of variance.

If the data record is lengthy, a sinusoidally-varying term can be fit to the data and this component then removed, leaving only the residuals. Such removal of seasonal variability is extensively done in surface water hydrology. Nevertheless, for many ground water problems, the ability to "fit" a sinusoidally-varying term to a very brief record is suspect. If the variance of the time series is used, without removal of the seasonal variability, the variance will be large (because it contains the periodic component and the deviations from the periodic component) and the t-test will probably fail.

As the example demonstration, consider the evaluation of whether a clay cap has had a significant impact on water table levels in a landfill. The changes in water levels for each month within a year may be used to identify whether changes are significantly different from zero. Field-monitored data are contained in Table 3, the first twelve of which correspond to the pre-capping conditions and the final twelve to the post-capping conditions. There is some seasonal variation apparent from the data since low values are apparent during the winter period and higher values are experienced in the late summer/early fall period.

The statistics, based on the twelve monthly values, are indicated at the bottom of Table 3. A pooled estimate of the assumed common variance is

$$S^2 = \frac{m S_m^2 + n S_n^2}{(m + n - 2)}$$

$$= \frac{12(.92)^2 + 12(.69)^2}{(12 + 12 - 2)} = .72$$

The standard error of difference of the two means is

$$S_m = \sqrt{.72 \left(\frac{1}{12} + \frac{1}{12} \right)} = .346$$

and the t is then calculated as

$$t = \frac{975.92 - 975.30}{.346} = 1.79$$

The number of degrees of freedom is 12+12-2 = 22. For a two-tailed test with 22 degrees of freedom and = 0.05, t = 2.07 and the impact of the clay cap (either up or down) is not shown to be significant.

Alternatively, if the seasonal variability is avoided by taking the difference between the water levels for respective months as per Table 4, the resulting set of calculations show

$$t = \frac{.62}{.89/\sqrt{12}} = 2.41$$

The number of degrees of freedom is 12-1 = 11. For a two-tailed test with 11 degrees of freedom and = 0.05, t = 2.20 and the impact of the clay cap is shown to be significant (i.e. $t > t_c$).

CONCLUSIONS

A number of alternative discrimination tests exist for use in assessing whether water quality is improving or deteriorating over time in response to remediation efforts at landfills. However, as was shown, the statistical tests are frequently constrained by limiting assumptions which are violated by such aspects as natural variability, errors in sampling methodologies, and the brevity of available data.

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Table 1 Summary of Statistical Discrimination Tests in Frequent Use

Type	Test	Major Assumptions	Example Applications
Parametric	Two sample t-test	(i) the distribution of the two samples have the same variance(*); (ii) the distributions are normal or gaussian	Rovers and McBean (1981) and McBean and Rovers (1984)
	Approximate t-tests (i) Satterthwaite's Approximation (ii) Cochran's Approximation to the Behrens-Fisher t-test (Cochran, 1964)	(i) relaxation of the assumption regarding variances, (ii) the distributions are approximately normal or gaussian. Note: This has been explicitly characterized by the coefficient of variation which must be less than unity, in RCRA (Federal Register, 1982).	McBean and Rovers (1985)
	Data-transformations prior to use of the two sample t-test	(i) the distributions of transformed variables have the same variance(*); (ii) the distributions are normal or gaussian	Rovers and McBean (1981)
	Pairwise t-test - when the sample populations are differenced	(i) the differences between the two samples are distributed as normal or gaussian	McBean (1985)
Non-parametric	Mann-Whitney test		

(*) a prior F-test indicates whether the sample variances are sufficiently alike to warrant the assumption that they are independent estimates of the same population variance.

Table 2 Summary Table of t-Test Statistics, Degrees of Freedom and Assumptions

Test	Two Sample t-Test	Satterthwaite Approximation to the Two Sample t-Test	Cochran's Approximation to the Behrens-Fisher test	Paired t-Test
t statistic	$t = \frac{\lvert \bar{x} - \bar{y} \rvert}{S\sqrt{\frac{1}{m} + \frac{1}{n}}}$	$t' = \frac{\lvert \bar{x} - \bar{y} \rvert}{\sqrt{\frac{S_x^2}{m} + \frac{S_y^2}{n}}}$	$t^2 = \frac{\lvert \bar{x} - \bar{y} \rvert}{\sqrt{\frac{S_x^2}{m} + \frac{S_y^2}{n}}}$	$t = \frac{\bar{D}}{\frac{S_D}{\sqrt{m}}}$ where $D_i = x_i - y_i$ for $i=1,\ldots m$ and $\bar{D} = \sum_{i=1}^{m} D_i$ and $S_D = \sqrt{\frac{\sum_{i=1}^{m} (D_i - \bar{D})^2}{m-1}}$
Degrees of Freedom	$df = m + n - 2$	$df = \frac{\left(\frac{S_x^2}{m} + \frac{S_y^2}{n}\right)^2}{\left[\frac{\left(\frac{S_x^2}{m}\right)^2}{m-1} + \frac{\left(\frac{S_y^2}{n}\right)^2}{n-1}\right]}$ Note: round 'df' down to the next nearest integer	df_x = t - tables with m-1 degrees of freedom; df_y = t - tables with n-1 degrees of freedom; $W_x = \frac{S_x^2}{m}$ and $W_y = \frac{S_y^2}{n}$ with the result the comparison t-statistic is $t_c = \frac{W_x t_x + W_y t_y}{W_x + W_y}$	$df = m - 1$
Comments	Since σ is unknown, it is replaced by S, the sample standard deviation. The same formulae are used with transformed data, as with untransformed data.			

Table 3 Impact of Clay Capping on Water Table Levels

Date	Water Table Elevation	Date	Water Table Elevation
Nov. 79	975.93	Nov. 80	974.91
Dec. 79	975.21	Dec. 80	974.59
Jan. 80	975.95	Jan. 81	974.59
Feb. 80	974.91	Feb. 81	974.73
Mar. 80	975.49	Mar. 81	974.61
Apr. 80	975.55	Apr. 81	975.39
May 80	974.70	May 81	975.77
Jun. 80	976.88	Jun. 81	975.78
Jul. 80	975.84	Jul. 81	976.71
Aug. 80	977.63	Aug. 81	975.97
Sep. 80	977.38	Sep. 81	975.72
Oct. 80	975.62	Oct. 81	974.87
Mean $\bar{x}$ =	975.92	Mean $\bar{x}$ =	975.30
Standard Deviation S =	.92	Standard Deviation S =	.69

Note:- Clay cap was placed in October 1980.

Table 4 Differences in Water Table
Before and After Clay Capping

Month	Difference in Water Table
November	1.02
December	.62
January	1.36
February	.18
March	.88
April	.16
May	-1.07
June	1.10
July	-.87
August	1.66
September	1.66
October	.75
Mean $\overline{\Delta x}$ =	.62
Standard Deviation S =	.89

APPLICATION OF LABORATORY COLUMN TESTING IN THE DESIGN OF REMEDIAL PURGE WELL SYSTEMS

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ABSTRACT

In 1978, about 18,000 litres of a chlorophenol/phenate solution leaked from a sawmill dip tank located approximately 120 metres from the Okanagan River in Penticton, B. C.. Results of field studies indicated that the chlorophenol/phenate migrated through a surficial alluvial aquifer toward the river and that the retardation factor for the contaminants was between 1.05 and 1.43. A purge well remedial operation recovered only about 40% of the spilled chlorophenol/phenate. More than 5 years after the purging operation, low levels of chlorophenol/phenate were still present in the ground water.

A column test to simulate the subsurface transport of pentachlorophenol/phenate was conducted in the laboratory under conditions which duplicated, as closely as possible, those in the field. Results suggest a retardation factor of about 1.2 and non-equilibrium (i.e. slow) sorption/desorption. The success achieved in the simulation indicates that these types of tests should comprise part of a waste site assessment and remediation program. Data can be obtained at relatively low cost and at an early stage in an investigation, and can be employed to provide a preliminary assessment of the probable efficiency of purging. In addition, the results can be applied to establish parameters and operating conditions that will improve the effectiveness of costly field tests that must precede the design of an optimal purging system.

INTRODUCTION

In 1978, about 18,000 litres of a chlorophenol/phenate solution leaked from a sawmill dip tank located about 120 metres from the Okanagan River in Penticton, B. C. (Fig. 1). The solution was a buffered alkaline mix of sodium tetrachlorophenate and sodium pentachlorophenate with an estimated concentration of 7500 mg/L total chlorophenate. A hydrogeologic investigation indicated

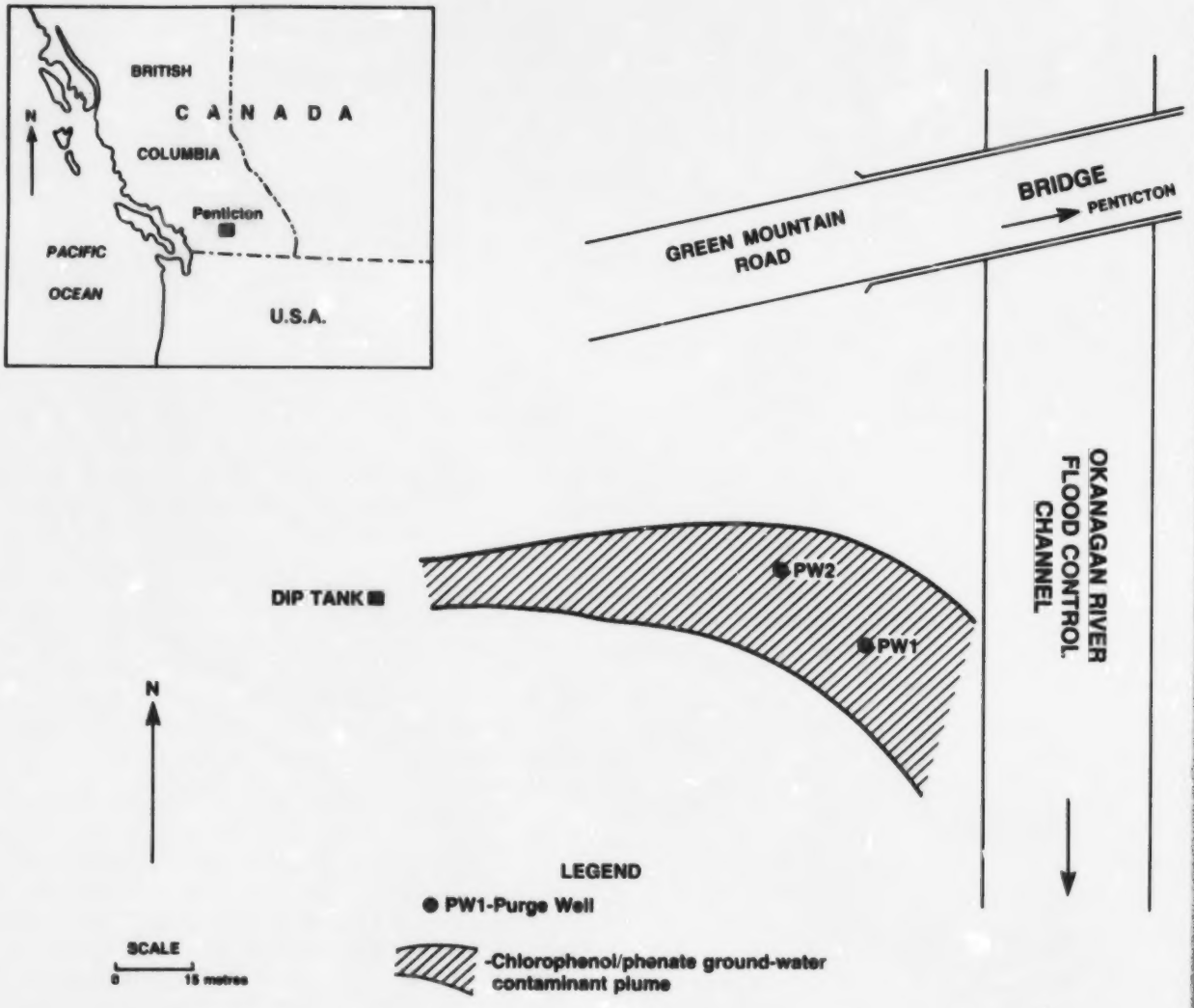

Figure 1: Chlorophenol/phenate spill site near Penticton, British Columbia.

that the chlorophenol/phenate migrated through an unconfined (water table depth between 5 and 5.5 metres), alluvial aquifer toward the river (Fig. 1) and that the retardation factor (i.e. average velocity of ground-water/average velocity of contaminant transport) for the contaminants was between 1.05 and 1.43 (Atwater and Liebscher, in prep.). Retardation factors were calculated on the basis of estimates of ground-water flow rates (2.25 - 3.00 m/day) and observed velocities of chlorophenol/phenate migration (~2.15 m/day).

About six weeks after the spill, a purging operation was carried out at the site to minimize the seepage of chlorophenol/phenate into the river (Atwater and Liebscher, in prep.). Most purging was conducted by pumping two 15 cm diameter production wells (Fig. 1) at a combined rate of up to 200 cubic metres per day for 89 days. In total, 10,900 cubic metres of contaminated ground water containing about 40% of the spilled pentachlorophenol/phenate were recovered and treated. At the end of the purging operation, only relatively low levels (1 - 2 mg/L) of pentachlorophenol/phenate remained in the recovered water (Fig. 2). The low recovery efficiency of only 40% was attributed to tetrachlorophenol and pentachlorophenol precipitation which should have occurred when mixing of the spilled solution and ground water reduced the pH below 8.9. Subsequent slow dissolution of the precipitates was suggested to account for the persistence of chlorophenol/phenate at the end of the purge operation. Analytical results for water samples collected from piezometers in 1984 indicated that low levels (<350 ug/L) of chlorophenol/phenate were still present in ground waters downgradient from the spill site (B. Graham, personal communication).

The availability of field data concerning the behaviour of chlorophenol/phenate in the ground-water flow system at Penticton represented an opportunity to evaluate the potential of laboratory column experiments to simulate transport of these compounds in the subsurface. As a result, a column apparatus duplicating, to the greatest extent possible, the conditions believed to exist in the shallow aquifer at the spill site was assembled in the laboratory. A test was then carried out using pentachlorophenol/phenate to produce retardation and sorption/desorption kinetics data that could be compared with field results.

METHODS

Sediment and water for use in the column simulation were obtained from uncontaminated parts of the aquifer at the spill site. Aquifer sediment was recovered in 5.08 cm diameter thin-walled aluminum tubing. Ground water was pumped from a PVC piezometer, filtered through a 0.1 um membrane to remove particulates and microbes and stored in the dark at 4 C until use in the experiment.

A commercially available, 4.4 cm diameter glass column (Amicon Wright: cat. no. 85941) was used for the experiments. Laboratory batch tests indicated that the materials of the column

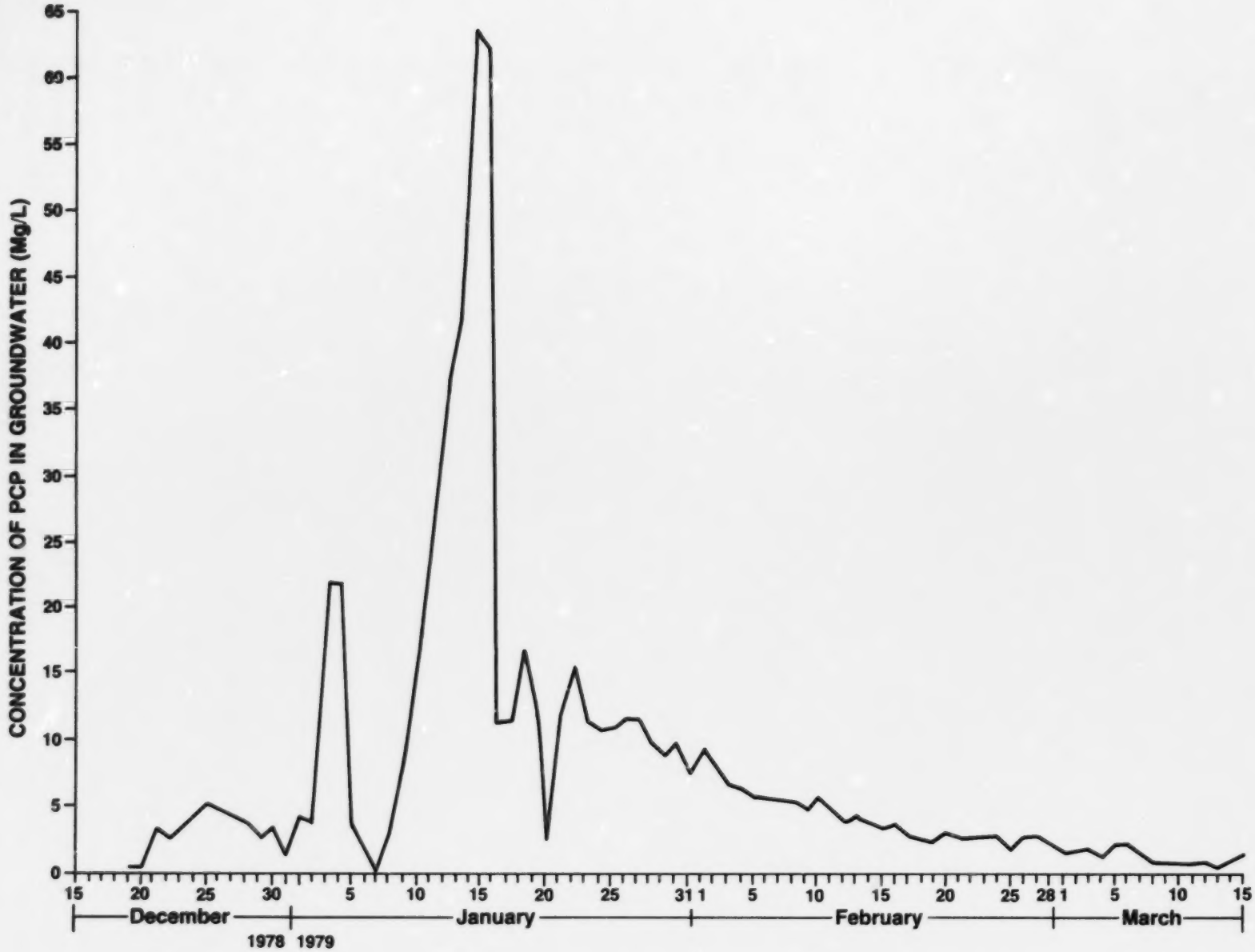

Figure 2: Concentration of pentachlorophenol in ground waters extracted during purge operation.

did not sorb significant amounts of chlorophenol/phenate. The column was packed with dry sediment that was compacted (final sediment column length of 18.6 cm and porosity of 38%) to the original density in the core collected from the field. Sterilization was achieved by heating the packed column to 100° C for twenty-four hours while passing water saturated air through the sediment. This procedure was repeated three times.

The column apparatus was assembled in a cold room maintained at 8° C, the temperature of ground waters at the spill site. Uncontaminated ground water was circulated through the column with a Sage Model 375A peristaltic pump for three days to condition the sediments and establish the desired flow rate. The test was started by switching the column input from uncontaminated ground water to ground water containing 5.4 mg pentachlorophenol/phenate/L (no tetrachlorophenol was added) and 20 mg iodide/L. This spiked ground water was introduced for 18 hours, after which the input of uncontaminated water was resumed for an additional 46 hours. Samples of the outflow from the column were collected at hourly intervals. Throughout the 64 hour test, the flow rate ranged from 18.1 to 19.2 mL/hr and averaged 18.7 mL/hr, which is equivalent to a ground-water flow velocity of about 77 cm/day. A flow rate less than the average field ground-water velocity was selected because the sands recovered in the cores are finer than the majority of materials in the aquifer and should be characterized by slower than average flow velocities.

Effluent samples were analysed for iodide by ion chromatography (Dionex model 12S) using an electrochemical detector. The organic contaminant, pentachlorophenol/phenate, was measured by High Performance Liquid Chromatography (HPLC) employing a UV detector. The pH of the influent and effluent waters were determined with an Orion 801A meter and combination electrode.

Interpretation of results was assisted using a computer code denoted as VANGEN which is a numerical implementation of the analytic solution described by Van Genuchten and Wierenga (1976). In this model, the liquid phase is subdivided into mobile and immobile regions, diffusional transfer between these two regions is considered to be proportional to the concentration difference, sorption processes are regarded as instantaneous and the sorption isotherm is assumed to be linear.

RESULTS

Changes in the concentrations of iodide and pentachlorophenol/phenate in the effluent from the column during the test are shown in Figure 3. For both components, concentrations (C) are expressed in terms of input levels (Co) in the contaminated ground water. The pH of waters during the experiment was generally in the range of 7.1 to 7.6 and, therefore, the predominant organic contaminant species was pentachlorophenate (>99%).

Measurements of the areas beneath the two curves in Figure 3 indicate that, within the limits of uncertainty, all of the iodide and pentachlorophenol/phenate that was introduced into the

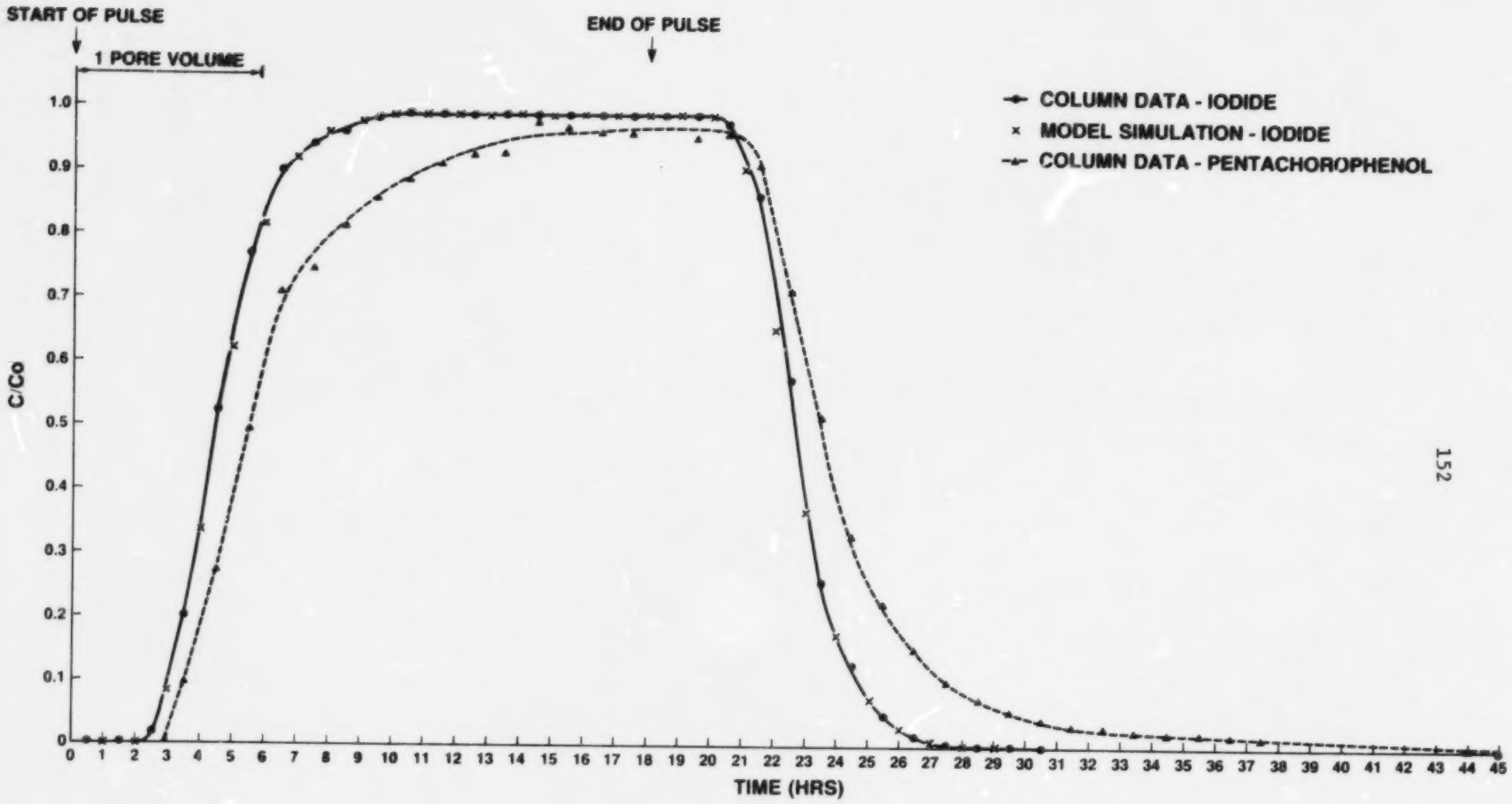

Figure 3: Column results for iodide and pentachlorophenol and model simulation of iodide pulse.

column can be accounted for in the effluent. Consequently, there was no irreversible uptake of significant quantities of either component during the experiment.

Simple estimates of the retardation factor for the pentachlorophenol/phenate can be made by comparing the relative positions of the mid-points of the rising limbs or the centres of mass of the pulses. On the basis of times to reach C/Co = 0.5, a retardation factor of 1.23 is indicated, whereas calculations incorporating centre of mass positions suggest a retardation factor of 1.12. Both of these values are within the range, 1.05 to 1.43, determined from field observations.

Another estimate of the retardation factor for pentachlorophenol/phenate can be determined by model simulation. The iodide curve in Figure 3 was first approximated using the VANGEN computer code and assuming no sorption on the sediment. The closest match (model points indicated on Fig. 3) was achieved with a fraction of mobile water of 0.80, dispersion coefficient of 88 cm2/day (dispersivity of 1.14 cm) and mass transfer coefficient of 0.018. With these parameters fixed, the retardation factor and fraction of sorption sites within the mobile phase were then varied to try to approximate the shape of the pentachlorophenol/phenate pulse. The best model fit for the mid-points of the rising and falling limbs of the pentachlorophenol/phenate pulse was obtained with a retardation factor of 1.2 (Fig. 4).

Although the model curve in Fig. 4 matches the mid-points satisfactorily, it does not approximate closely the upper portion or the tailing section of the experimental pulse. The flattened upper portion of the experimental pulse and, especially, the presence of a long tail indicate that non-equilbrium sorption/desorption (i.e. sorption/desorption reactions are kinetically controlled and occur more slowly than predicted by an equilibrium model) is occurring (Bahr et al., 1984).

DISCUSSION

The column experiment appears to have succeeded relatively well in simulating the rate of transport of pentachlorophenol/phenate in the shallow aquifer at the Penticton site. Retardation factors determined from C/Co times, centre of mass positions or modelling average about 1.2 which is in the middle of the range determined from field results.

Atwater and Liebscher (in prep.) suggested that the precipitation of chlorophenols was responsible for the low recovery efficiency of the purging operation, and that the subsequent dissolution of the precipitates accounted for the persistence of pentachlorophenol/phenate in the later extracted waters. The low recovery efficiency is likely a consequence of the formation of precipitates, however, the persistence of pentachlorophenol/phenate at levels of 1 to 2 mg/L (Fig. 2) or 2% to 3% of maximum concentrations may not be entirely due to precipitate dissolution. During the field purging operation, 10,900 cubic meters of ground water, or about 5 pore volumes (in terms of the volume of the contaminant plume) were extracted. Since some water discharged from the purge wells was derived from

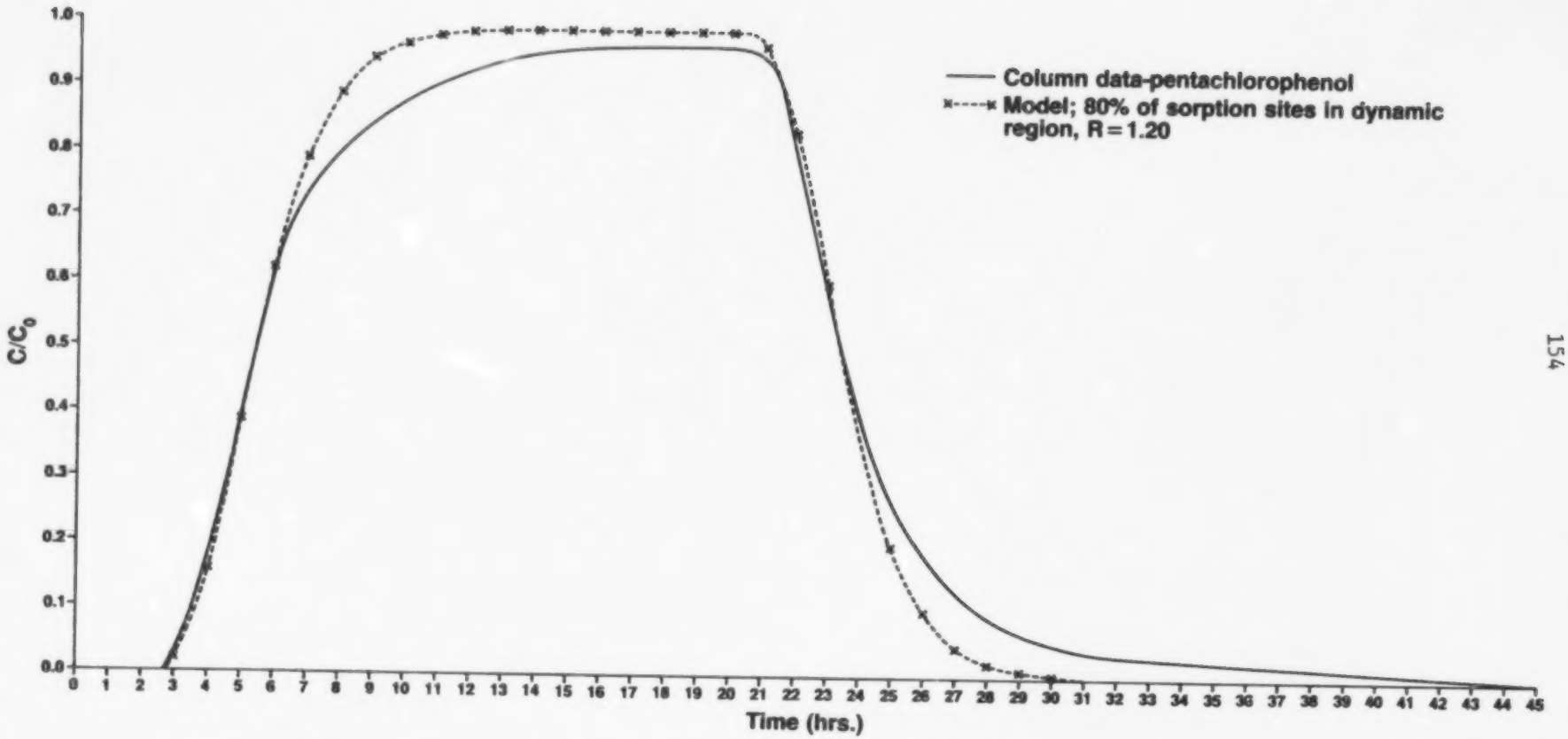

Figure 4: Column results for pentachlorophenol and column simulation.

adjacent uncontaminated parts of the aquifer and possibly the river, the number of pore volumes removed from the contaminated zone was probably considerably less than 5. On the basis of the experimental results (Fig. 3), removal of about 2 to 3 pore volumes should result in concentrations being reduced to 2% to 3% of maximum. Consequently, the persistence and final levels of chlorophenol/phenate in the purge waters can be accounted for in terms of the behaviour of pentachlorophenol/phenate indicated by the experimental simulation without any contribution from precipitate dissolution.

The concentrations of pentachorophenol/phenate measured in ground waters at the site in 1984 suggest that precipitate dissolution was probably not a major source of chlorophenol/phenate at the end of the purging operation. If it is assumed that all the pentachlorophenol/phenate in the ground water at the site in 1984 was the result of the dissolution of chlorophenol precipitates, then the highest concentrations (~350 ug/L) are likely representative of the maximum contribution from this source. Since concentrations at the end of the purge operation were on the order of 1 to 2 mg/L, it appears that no more than 30% of the chlorophenol/phenate could have been derived from precipitate dissolution.

If the results of the simulation experiment had been available soon after the spill occurred, the operational parameters of the purge system could have been altered to increase efficiency. Since slow desorption of chlorophenols would be expected, lower and/or pulsed pumping rates would have been preferable to increase the efficiency of removal. Lower pumping rates would also have resulted in reduced inflow from uncontaminated parts of the aquifer or the river. In addition, it would have been apparent that at least 5 pore volumes would have had to be extracted to remove all pentachlorophenol/phenate not present as a precipitate.

ROLE OF COLUMN TESTS IN THE DESIGN OF PURGE WELL SYSTEMS

The laboratory simulation appears to have duplicated field conditions at the Penticton site closely and the results, if they had been available soon after the spill occurred, could have been applied usefully to improve the effectiveness of the purging operation. The success of the experiment indicates that column tests of the type conducted, or with modifications to address specific concerns in more detail, should be included in waste site investigation programs where purging is a possible remedial alternative. These experiments can produce important data at relatively low cost early in an investigation when aquifer sediments and ground water are being collected and analysed for site assessment purposes. The results relating to the retardation and sorption/desorption kinetics of contaminants are particularly useful for providing a preliminary evaluation of the potential effectiveness of purging as a remedial measure. For example, only contaminants which have low retardation factors and relatively rapid desorption kinetics are likely to be ammenable to efficient removal by simple purging.

In situations where the simulated behaviour of a contaminant or contaminants indicates that purging may be practical, the results of the column experiments can be employed further to assist in defining design parameters (e.g. scale of the test, pumping rates or schedules) for subsequent field tests that are a necessary step in the planning of an optimal purging system. Since these field tests are a very costly component in the development of a remedial purging plan, column data that can significantly increase the probability of success is extremely valuable.

The column experiment in this study was conducted primarily to show that laboratory simulation of aquifer conditions is possible and that the information may be usefully applied in evaluating and designing remedial purge systems. Consequently, the results do not demonstrate fully the potential that the technique may have in remedial programs. For example, once the ability to simulate flow system conditions has been achieved, the apparatus may be employed to evaluate modifications in purging conditions (e.g. pulsed pumping or variable pumping rates) or enhanced purging (e.g. the introduction of chemicals that might improve extraction of the contaminants). In all cases, however, the major advantage associated with column simulation will be the capability to assess different purging strategies under more controlled conditions, at much less cost and in considerably less time than is possible with field tests.

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AUTHORIZATION OF MOBILE PCB DESTRUCTION FACILITIES IN ONTARIO

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BACKGROUND

Polychlorinated biphenyls (PCBs) are a class of synthetic organic compounds which have had many industrial applications. The use and disposal of PCBs were restricted after concerns developed about their environmental and health effects during the 1960's and 1970's. There are presently no facilities approved for the destruction of PCBs in Ontario. PCB wastes in Ontario must be stored in approved storage sites awaiting a means of ultimate disposal. Indefinite storage of PCBs is an unsatisfactory way of removing these substances from contact with the environment because storage sites and containers are subject to accidental spills and leaks. The lack of an ultimate disposal method serves as an incentive for illicit disposal methods. Hence, it was apparent that facilities are required in Ontario to provide a safe and cost-effective means of destroying PCBs.

Previous attempts to establish either destruction or permanent storage facilities for PCB wastes in Ontario have been unsuccessful due to local public opposition to the establishment or use of long term fixed facilities.

Mobile PCB destruction facilities have been approved for use in the U.S. and more recently in other provinces. Such facilities have the advantage of being able to treat PCB wastes within a regional area and then move on to other locations. Thus, any potential local exposure to PCBs, albeit, owuld be minor emitted from destruction facilities would occur for only the short period of time that facilities operated at a given location. Ontario decided that mobile PCB destruction facilities offered an immediate means of addressing the PCB waste disposal problem in Ontario. Present approvals processes for the operation and siting of such facilities were developed for fixed facilities and would require a public hearing for each new facility and site. Furthermore, the siting of facilities on public lands and/or destruction of public sector wastes in such facilities may require an environmental assessment to be undertaken. Therefore, an approvals process specific to mobile PCB destruction facilities had been proposed to facilitate their use in Ontario. Public input into the development of the approvals process and public acceptance of the concept of using mobile PCB destruction facilities has been sought.

PUBLIC INPUT INTO THE PROCESS

Because of the environmental and health concerns over PCBs that arose in the 1970's, the extensive media coverage of PCB incidents and the heightened public awareness about environmental contaminants the Ontario public has become increasingly apprehensive about the location and operation of any facility to treat PCBs.

Recognizing the need to inform the public about the properties and effects of PCBs, the need for ultimate disposal methods and the need for public involvement in plans to destroy PCB wastes, the Ministry embarked on a program to consult with the public on its proposals to facilitate and regulate the siting and operation of mobile PCB destruction facilities in Ontario.

Circulation of a Discussion Paper (February 1983)

A discussion paper entitled "Guidelines for the Regulation and Siting of Mobile PCB Destruction Facilities - A Discussion Paper" was distributed to 180 municipalities reported having sites where PCBs were stored, 350 public utilities and a variety of associations, proponents of technologies and interest groups. Site selection and operational criteria that could be used as a basis for a regulation under the Environmental Protection Act were presented for discussion.

The majority of the 58 responses were supportive, neutral or raised issues that could be addressed. However, the number of responses represented less than 10% of the distribution. The small number of responses could be interpreted as a lack of interest in the regulatory proposals, a general lack of opposition to them, confidence in the Ministry's capability to regulate mobile PCB destruction facilities and/or a lack of interest in the abstract concept of participation in decisions on regulating facilities unless and until the facilities are actually about to appear in "someone's backyard".

The Ministry concluded that the initial response to its plans had been favourable enough to proceed with the development of a specific approvals process for such facilities, together with an active public consultation program to increase the level of public participation.

In September, 1983, a Task Force, chaired by my branch, was formed to expedite the development of the regulatory proposals and to formulate and implement a public consultation plan which would seek public acceptance of the concept of using mobile facilities and obtain public input to the development of requirements for the operation and siting of these facilities.

The consultation plan was integrated with the development of the regulatory proposal as follows:

1. Informal discussions with municipal staffs, potential proponents, industry, labour and public interest groups (as a follow-up to the February 1983 Discussion Paper).
2. Development of revised proposals.
3. Presentations to municipal councils and/or committees of councils outlining the nature of the PCB problem and the basis of the revised proposals.
4. Circulation of revised proposals for public comment.
5. Public information sessions in target municipalities to explain the proposals, identify local issues and increase the level of public awareness of the PCB problem.
6. Receipt and analysis of comments on revised proposals.
7. Further revisions of proposals to reflect public feedback;
8. Submission of the Ministry's proposals to a public hearing under the Public Inquiries Act.

Consultation Prior to Proposal Revisions (August 1983)

From August, 1983 until the issuance of the revised proposals on May 22, 1984, members of the PCB Task Force met with municipal staffs in 20 communities, several industries and utilities owning substantial quantities of inservice of waste PCBs, as well as with potential proponents, public interest groups, the Ontario Federation of Labour and representatives from the U.S. Environmental Protection Agency and Environment Canada. The meetings were to provide information on the Ministry's plans to identify potential concerns and to obtain informal feedback on some approaches and details being considered for incorporation into the Ministry's regulatory proposals. The meetings and discussions were unstructured and informal to facilitate a frank exchange of views.

Public Information Sessions (May 22, 1984)

Coincident with the issue of the Ministry's revised proposals to a mailing list of over 800, 18 public information sessions were held. These sessions were conducted as informal "open houses" in which the public were able to discuss their questions and concerns with Ministry staff on an individual basis. Information on the history and background of PCBs, environmental and health concerns, the Ministry's regulatory proposals and illustrations of two kinds of mobile technologies were displayed. A videotape presentation on the background to the PCB problem and the mobile destruction concept, including interviews with representatives of two potential proponent technologies in the United States was shown. An audio-visual slide presentation dealt with the history of PCBs and associated environmental and health concerns in greater detail. In addition, copies of the Ministry's proposals and several background references were available as handouts.

Some 455 people attended the information sessions. The information sessions were well received and general support for mobile destruction facilities was expressed. Visitors at the sessions included representatives from local industry and public utility groups, local media, public interest groups, labour, ratepayer associations, potential proponents, municipal councillors and staff, boards of health, and the public.

Most visitors appreciated the need to destroy PCB wastes and accepted the concept of mobile facilities. Some concerns over air emissions from facilities were expressed as well as a reluctance to adopting U.S. technology where Canadian alternatives might be available.

HEARINGS OF THE ROYAL COMMISSION ON THE PROPOSED REGULATORY CONTROL OF PCBS

The PCB task force evaluated all of the suggestions and revised the various components of the proposal to incorporate as many of the suggested changes as possible. All the components were then drawn together into the document "Preliminary Hearing Document on Proposals for the Regulation of Mobile PCB Destruction Facilities in Ontario, September 1984".

After acceptance by the Ministry, the Hearing document was extensively circulated and the Minister formally submitted the document to the Royal Commission for a full public Inquiry.

The public consultation program culminated in public hearings to be held before a Commission constituted under the Public Inquiries Act. The Ministry of the Environment assumed the proponent's role in presenting the

proposed regulatory and administrative framework to the Commission. Funds were made available to the Commission to help defray expenses of parties to the hearing.

This regulatory and administrative framework was developed and presented during the hearing:

a) a specific regulation under the Environmental Protection Act setting out the standards and criteria for siting and operation of facilities and removing the present hearing requirements;

b) an amendment to Regulation 293 under the Environmental Assessment Act relieving proponents of the requirement to undertake an environmental assessment where public lands were proposed for the siting of a facility and/or a public sector client wished a private sector operator of a facility to dispose of its PCB wastes;

c) testing requirements by which proponents may demonstrate that their facilities can comply with Ministry standards, criteria and guidelines;

d) an administrative package incorporating requirements not covered in the two proposed regulations, and Ministry commitments to inspect and monitor mobile PCB destruction facilities and provide for public input to selection of a site or sites.

The requirements in this framework were based on existing Ministry guidelines, regulations and criteria for the protection of human health and the environment with additional requirements incorporated to address concerns raised during the public consultation program.

The proposals were generic in nature and were designed so that any facilities which could demonstrate that they met the proposed requirements could be approved. No specific technologies were selected or recommended. The proposed regulatory and administrative framework set out the ground rules by which facilities and their technologies would be allowed to locate and operate in Ontario.

Two classes of facilities were proposed, those which use incineration and other thermochemical processes for the destruction of the wastes and those which use a chemical to destroy PCBs and allow the associated organic matrix to be recovered.

The package included requirements for spill prevention, emission control, continuous process monitoring, automatic process shutdown mechanisms, record keeping, contingency planning, and public input to site selection. The time that facilities may operate in any one municipality was limited and they may not return for a specific period of time without prior agreement from the Ministry and local municipality. Operators were to post a performance bond and the Ministry was to carry out monitoring of the environment before and after operations to determine any need for remedial measures to restore the site to an acceptable condition. Monitoring results were to be made public. Minimum setback distances from other land uses were specified, as were environmental quality guidelines and criteria to be met for discharges to the air, water and soil. Frequent inspections of the site were to be undertaken by Ministry staff, who were to have authority to shut

down facilities upon detection of violations of approved conditions of operation.

REPORT OF THE COMMISSION

After more than six months of hearings involving nine full time parties and 81 part time parties which produced some 13,870 pages of transcripts and 185 exhibits based on the evidence provided by 96 witnesses, the Commission delivered its report to the Minister on July 3, 1985. The report endorsed the key elements and principles of the Ministry proposal in these words:

"The Commission recommends that the proposed regulatory program for mobile PCB destruction facilities operating on temporary sites in Ontario be approved subject to the amendments and conditions included in this report."

The Commission then listed some 48 specific recommendations, most of which merely confirmed working improvements or corrections which the Ministry had already agreed during the course of the hearing would clarify or improve upon the working used to set out the proposal.

The major aspects of the Commission specific recommendations to the Minister were:

- "Mobile PCB destruction facilities should be exempted from the provisions of the Environmental Protection Act requiring technology and site specific hearings."
- That a third category, Class 3 sites, be added to the regulation to allow for the control of mobile PCB chemical decontamination facilities that process mineral oil with low levels of PCB concentrations in transformers insitu where oil is to be reused in the transformer.
- A destruction efficiency of six nines 99.9999% should be specified for PCB destruction to augment Ontario's use of ambient air standards and dispersion modelling to regulate emissions.
- Separation distances for the operation of Class I (incinerator type) facilities should be increased from the proposed 100 metres to 250 metres.
- A trained Ministry inspector should be present at the site at all times for the operations of Class 1 facilities.
- Proponents must "provide proof of insurance or other funds adequate, in the judgement of the Director, to provide compensation or redress for bodily injury and for property and environmental damage..."
- Transportation of PCB wastes into Ontario for the purpose of destroying such waste in mobile destruction facilities should be prohibited.

As well, the Commission offered these suggestions for the Minister to follow up on with the Ministry of Labour and Environment Canada:

- The Ministry of Labour be urged to designate PCBs, dioxins and furans as substances to be regulated, and to establish standards for air quality guidelines for these substances in the workplace.
- MOE, together with Environment Canada, consider incentives for removing PCBs from the environment.

MINISTER'S DECISION

On September 6, 1985, the Honourable Jim Bradley, Minister of the Environment, announced his decision on how the government will proceed with the Commission recommendations and the proposed regulatory and administrative framework. Ontario's action plan will have four parts:

- A new regulation (using the proposed regulation with amendments to incorporate the recommendations of the Commission) will provide clear ground rules to ensure safe and effective operation and control of destruction facilities.

- Certificates of Approval, based on thorough evaluation will ensure that approved equipment can in fact do the job.

- Communities in which PCBs require destruction will have a voice in the decision.

- The Ministry of the Environment will continue to inspect PCB waste storage sites and spill sites, will provide full-time inspection of any PCB incineration and will appropriately supervise other destruction operations.

It goes beyond the original proposal and the recommendations of the Commission in one key area, all PCB-incineration proposals will have full public hearings on the technology to be used and the site approval. The review procedures for Class II and III technologies will be those set out in the proposal document.

The Minister indicated that the measures set out to ensure public awareness and involve the community in the application of destruction technologies have been expanded and improved upon to go beyond even the recommendations of the Commission.

The Minister stressed that our Ministry would not be the proponent or driving force for using PCB destruction facilities at any specific location except under very unusual or urgent circumstances. We expect that the companies with the various sophisticated mobile PCB destruction will be very shortly submitting applications for technology approval. Since it may take some time to arrange the destruction schedule, and finalize the site planning, application for site approval might lag behind the technology applications. Although our final regulation will not be in place much before the end of 1985, proponents are able to proceed because they already have the detailed requirements spelled out in the original proposal document. The proponent companies with mobile PCB destruction are already proceeding with the approval process. We hope that four technologies will be well on their way to approval by Christmas of this year.

The Minister is looking to the owners and custodians of PCBs -- those in use and those currently stored as waste -- in cooperation and consultation with their neighbours, to work together and get on with the job of safe destruction of PCBs. These are the people most intimately and personally involved and they are the people living under the constant cloud of apprehension until these chemicals are implemented.

You might be of interest to know that we have appointed an internal implementation committee which is developing these very specific documents in response to the recommendations of the Commission of Inquiry of as a continuation of other PCB management efforts:

- An application form for Mobile PCB Destruction facilities.
- Guidelines for proponents on how Quality Assurance/Quality Control (QA/QC) aspects are to be addressed in applications for Certificates of Approval.
- A guidance manual for handling applications for approval of technology and sites to be used by approvals staff (head office or Regional) and to provide guidance of proponents and the public on how applications will be evaluated.
- The Ministry guideline document "The Origins and Management Of PCB Wastes, November 1984" is being updated to facilitate its use by MOE staff, the owners of PCB wastes, potential destruction proponents and interested public.
- A revision of the administrative direction upon which regional staff have their inspection and enforcement activities with regard to PCB wastes.

As well, Ministry staff are playing important roles in the federal-provincial working groups which are developing various components of a nation-wide approach to the whole issue of PCBs and their safe removal from the Canadian environment. This work arose out of the spring meeting of the Federal Provincial and Territorial Environment ministers in Montreal. The details of the October 3rd second meeting demonstrate the progress being made on the national aspects of this issue.

In closing, I would like to thank you for this opportunity to outline how Ontario is proceeding with this one option for PCB destruction. We are working very hard to have the regulation, procedures and associated documents and staff training in place to permit destruction technologies to commence operation in the new year in Ontario.

Our process has involved a discussion with representatives of the various interests and represents the product of their working together on resolving this issue. We know from the many recent news stories that the problem cannot be exported to someone else's backyard but must be solved here. It will be a very exciting 1986.

FULL-SCALE SEQUENCING BATCH REACTOR USE IN A COMMERCIAL HAZARDOUS WASTE FACILITY

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ABSTRACT

This paper describes the program used to prove the technical feasibility and the economic advantage of using a full-scale Sequencing Batch Reactor (SBR) for the treatment of aqueous organic waste materials at a commercial hazardous waste treatment facility. Efforts were focused on determining the reactor's treatment efficiency based upon phenol and Total Organic Carbon (TOC) removal rates, as well as showing the energy saving benefits which resulted from using the reactor prior to carbon adsorption treatment for the removal of organics. Both bench- and full-scale trials were performed involving a wide variety of feed streams, reactor operating strategies and temperatures.

The results of this demonstration showed that superior aqueous organic waste treatment is effected by the use of an SBR system as compared to previous carbon adsorption operations and that significant financial savings can be realized due to a reduction in facility operating costs.

INTRODUCTION

Background

Previous Operations. The wastewater treatment facility operated by CECOS International in Niagara Falls, NY treats aqueous wastes generated from multiple industries. The entire treatment plant may be conceptualized as operating in two physically distinct phases. The first phase of the system is designed to remove the inorganic contaminants contained within the wastewater, while the subsequent second phase is designed to remove the organic contaminants.

Phase I of the Niagara Falls facility (Figure 1) performs the chemical oxidation of organics using waste oxidizers such as dichromate, reduction of inorganic heavy metal oxidizers, lime addition for acid neutralization and metal hydroxide precipitation, and sludge dewatering via filter press.

The effluent from the first phase of the treatment system is then transferred via pipeline to the second phase in the process scheme (Figure 2). Phase II of the wastewater treatment system, before the installation of the SBR, involved pH adjustment in Tank L-8 using hydrochloric acid, sand filtration, organic removal via three granular activated carbon columns (a fourth column is used as an operating stand-by) and biological treatment in an aerated tank (Tank L-10). No provisions were made for biological solids recovery in the aerated tank. The limitations on various effluent parameters which must be met before discharge are summarized below in Table 1.

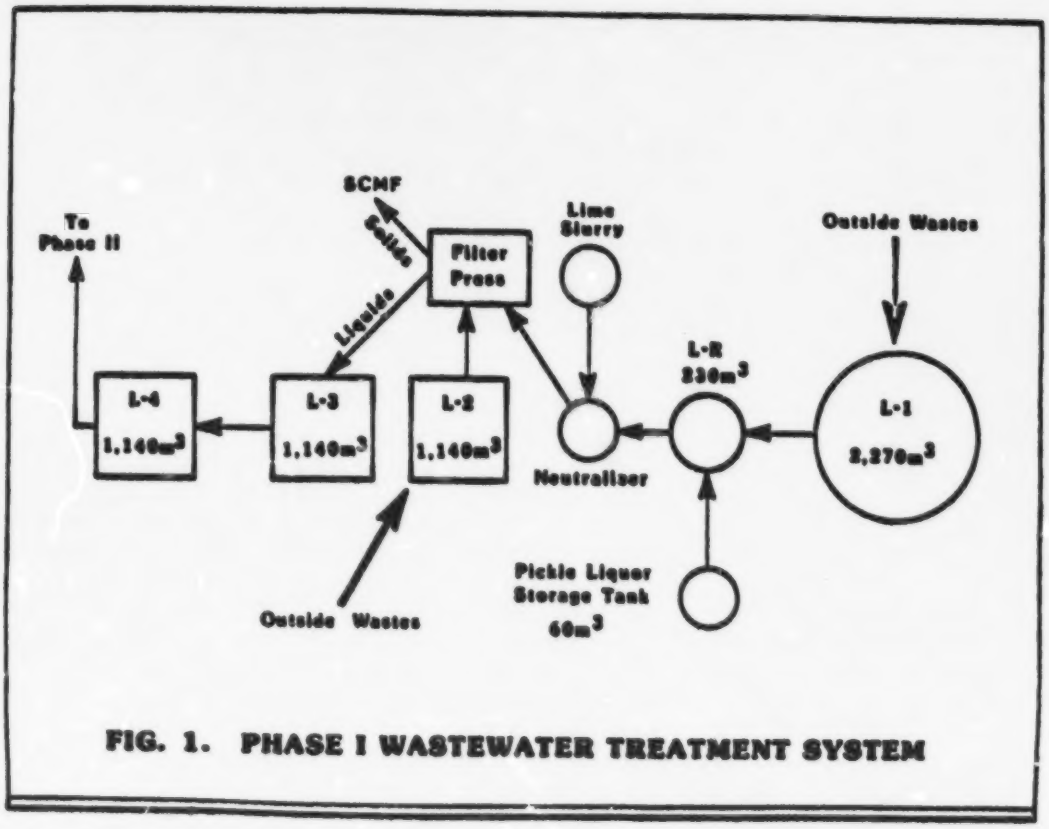

FIG. 1. PHASE I WASTEWATER TREATMENT SYSTEM

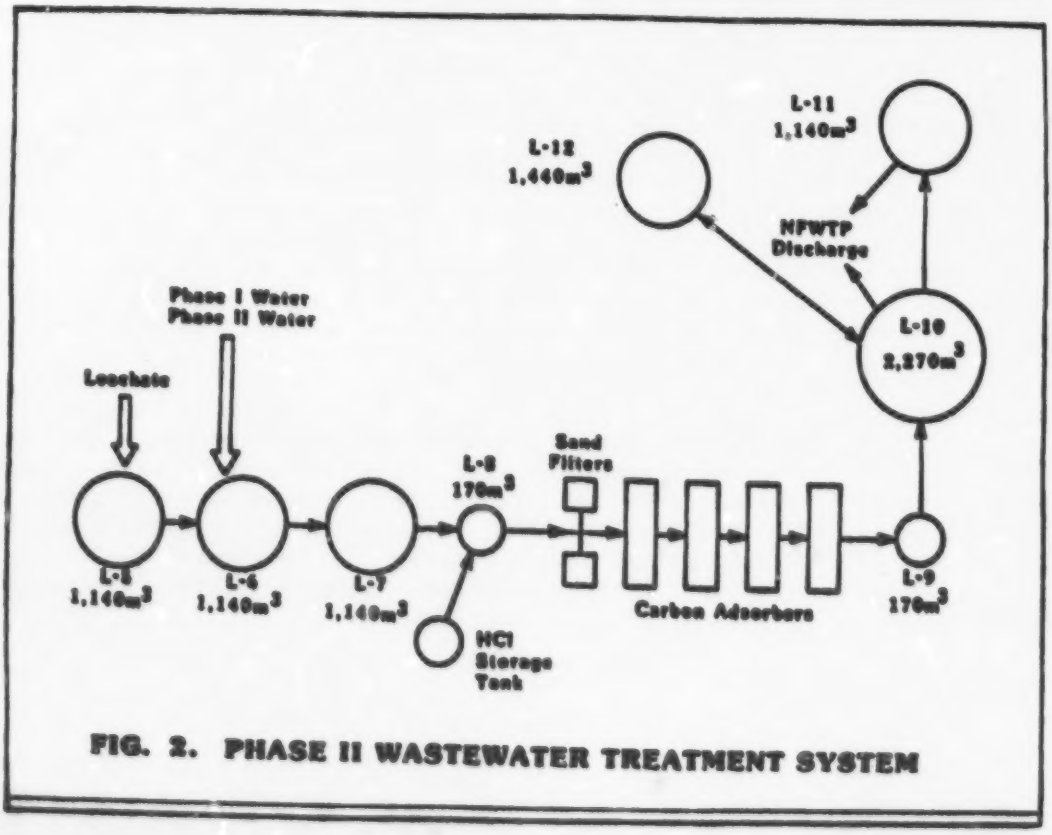

FIG. 2. PHASE II WASTEWATER TREATMENT SYSTEM

Table 1
EFFLUENT LIMITATIONS

Total Organic Carbon:	1,000 mg/l
Total Halogenated Organics:	0.1 mg/l
Volatile Halogenated Priority Pollutants:	1.0 mg/l ea.
Chemical Oxygen Demand:	1,040 kg/d
Phenol:	0.8 kg/d
Total Suspended Solids:	990 kg/d
Organic Phosphorus:	1.6 kg/d
pH (standard units)	5.5 - 9.0

Operational Difficulties. Due to the variability and toxic nature of the industrial wastewaters being treated, the CECOS system initially was designed so that primary removal of toxic organics was accomplished by adsorption on granular activated carbon, followed by additional treatment through biological action. The effectiveness of the biological degradation was not controlled and performance was directly related to seasonal fluctuations in temperature. Regeneration of activated carbon quickly became the single largest operating expense in the system. Each activated carbon column required a bed change approximately once every 15 to 30 days at a cost per change of roughly $20,000.

Remedial Actions. In an attempt to lessen the impact of these costs, CECOS attempted to generate biological activity in one of the holding tanks prior to carbon treatment. This was accomplished by installing a surface aerator in the tank and seeding the tank with commercially-available bacteria. It was hoped that biological degradation of organics in this tank would reduce the loading on the activated carbon, thereby reducing regeneration costs. However, the effect of this effort was minimal. It was believed that insufficient aeration did not raise the dissolved oxygen concentration in the tank to levels suitable for large-scale biological activity.

In late 1982, CECOS decided to significantly upgrade the organic-contaminant treatment phase of their facility. Concurrently, a request for a project proposal was offered to industry by the New York State Energy Research and Development Authority (NYSERDA) to co-fund a new and innovative biological wastewater treatment system which would demonstrate significant energy savings to its user. CECOS replied to this solicitation in February 1983 based on the use of an innovative technology, the Sequencing Batch Reactor (SBR).

The energy savings which CECOS expected to realize by use of SBR technology were based upon the reduction in activated carbon usage at the facility. By insertion of an SBR unit into the existing processing scheme prior to activated carbon treatment, the degradation of organic contaminants within the reactor would greatly reduce the loading imposed on the downstream carbon units. This decreased loading would mean longer times between carbon regenerations, which translates to fewer carbon changes per year. Because thermal carbon regeneration is extremely energy intensive, an energy savings of 760,000,000 KJ per year was estimated. In addition, the enhanced biological treatment effected by the SBR upon aqueous organic wastes was expected to reduce contaminant levels in the plant's effluent to concentrations well below those delineated in the facility's discharge permit. In July 1983, NYSERDA awarded CECOS a contract to build a full-scale SBR plant for the treatment of hazardous wastes.

Basic Operation of the Sequencing Batch Reactor

The SBR is a fill-and-draw activated sludge system. The SBR system is filled during a discrete period of time and then operated in a batch treatment mode. After treatment, the mixed liquor is allowed to settle, and the clarified supernatant is drawn from the tank. The major difference between the SBR and conventional continuous flow, activated sludge systems is that the SBR tank carries out the functions of equalization, aeration and sedimentation in a time sequence rather than in the conventional space sequence of continuous-flow systems. One advantage of a time orientation is that the relative tank volume dedicated to aeration and sedimentation, for example, can easily be changed, by adjusting a timing mechanism, in order to accommodate varying flowrates of influent wastewater. In contrast, the design of a conventional continuous-flow treatment system is based upon a fixed influent flowrate, and all necessary equipment is sized accordingly. For this reason, a continuous system cannot be adjusted easily to treat varying volumes of wastewater, whereas the SBR can be designed with the ability to treat a wide range of influent volumes. Thus, there is gained a degree of flexibility associated with working in time rather than in space. The actual operating scheme selected for use can be adjusted in accordance with the volume of liquid to be processed by modifying the settings of the control mechanism. The SBR is easily operated with or without biological phosphorus and nitrogen removal by providing anoxic and/or oxygenated conditions in a proper time sequence without, of course, employing the sludge recycle strategies common to the conventional biological nutrient removal facilities.

The operating cycle for a typical SBR, generally defined as a 24-hour interval, is divided into five discrete periods designated FILL, REACT, SETTLE, DRAW and IDLE as is shown in Figure 3. Central in this figure is one tank which is pictured in each of the five periods of one cycle. Also shown is the total cycle time that may be dedicated to each period and the purpose of and aeration strategy used for each period. A detailed discussion of each period of the SBR is provided below.

Fill. The influent to the tank may be raw wastewater or primary effluent. The influent may be pumped in or allowed to flow in by gravity. When more than one tank is used and the influent is added by gravity, some device (e.g. an adjustable weir or an automated valve) must be operated such that the flow is diverted to one tank or the other.

During FILL the influent wastewater is added to the biomass which remained in the tank from the previous cycle. The liquid volume is increased from the minimum level to the maximum of 100 percent. The period can be designed to terminate before the maximum level is reached by limiting the FILL time to a predetermined maximum. The time of FILL is shown to be 25 percent of the total cycle time in Figure 3, but will be more or less, depending upon the operational requirements of the treatment plant.

Aeration of the reactor can be initiated during the FILL cycle as well. Virtually any aeration system (eg., diffused, floating mechanical or jet) can be used. The extent to which the substrate is consumed during FILL is critical to the development of organisms with good settling characteristics. In addition, biological nutrient removal depends upon alternating conditions of low and high dissolved oxygen (D.O.). As a result, the aeration system must be able to provide a range of mixing intensities from zero to complete agitation. The completion of FILL is attained when the tank is full (as determined by a level indicator) or when a maximum time for FILL is reached. The wastewater flow can then be diverted to another tank in the SBR system, or terminated.

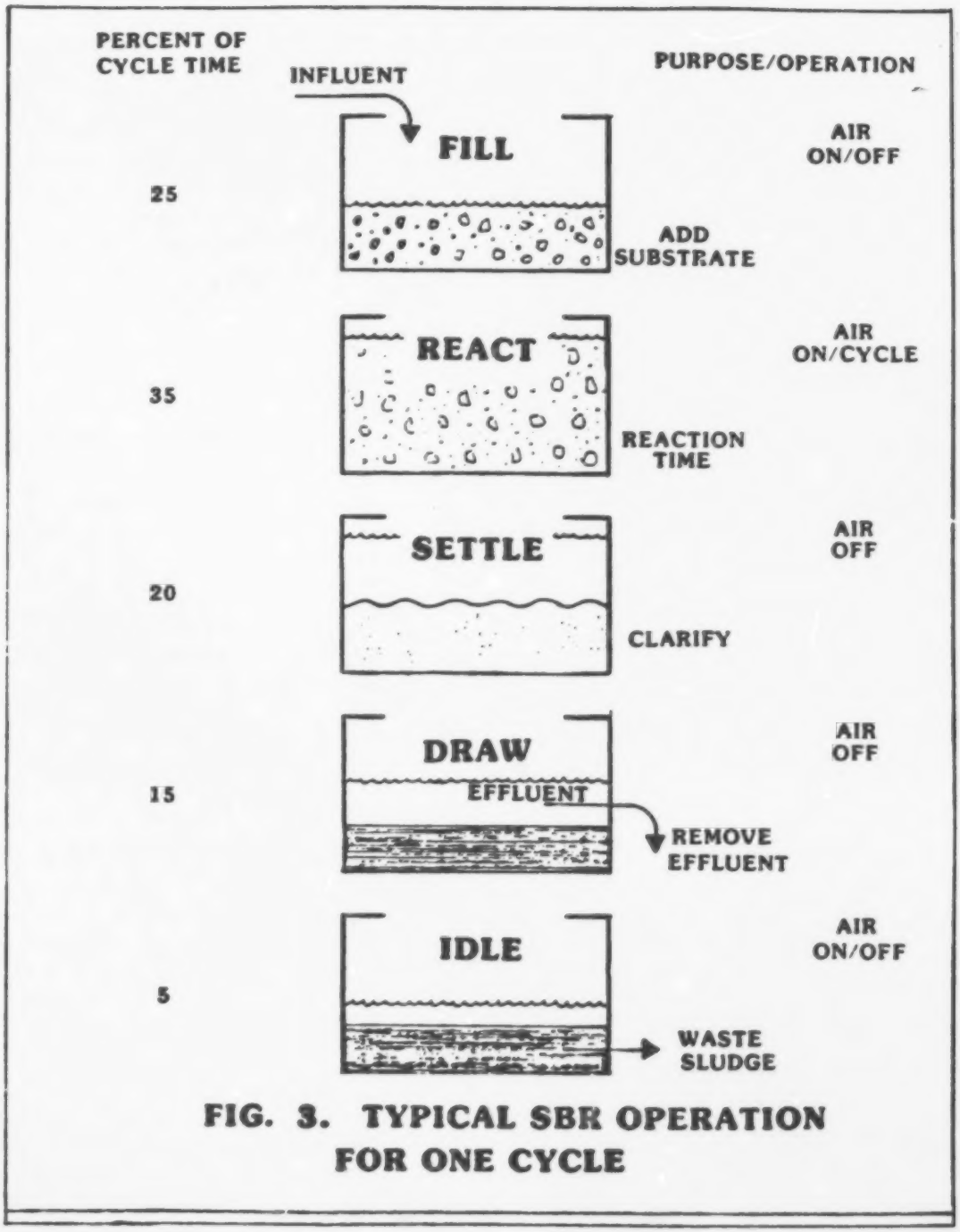

FIG. 3. TYPICAL SBR OPERATION FOR ONE CYCLE

React. Reactions which were initiated during FILL are continued during REACT. As in FILL, alternating conditions of high and low D.O. may be required. While Figure 3 suggests that the liquid level remains at the maximum throughout REACT, sludge wasting via mixed liquor removal can take place during this period as a simple means for controlling the sludge age. While 35 percent of the total cycle time is shown in Figure 3 to be dedicated to REACT, this can vary from a low of zero to more than 50 percent. The end of REACT is dictated by a time specification.

Settle. In the SBR, solids separation takes place quiescently in a tank which may have a volume of more than ten times that of a secondary clarifier in a conventional continuous-flow, activated sludge plant. This major advantage results from the fact that the aeration tank serves as a clarifier during the period that no flows enter the tank. Because all of the activated sludge remains in that tank until some fraction must be wasted, there is no need for underflow hardware normally found in conventional clarifiers. By way of contrast, mixed liquor is continuously removed from a conventional activated sludge aeration tank and passed through the clarifiers only to have a major portion of the sludge returned to the aeration tank. The time in SETTLE should be fixed between one-half and one hour so that the sludge blanket remains below the withdrawal mechanism during DRAW but does not rise (because of anaerobic gas formation) before DRAW is completed.

Draw. The withdrawal mechanism may take one of many forms. It may be as simple as a pipe fixed at some predetermined level with the flow regulated by an automatic valve or a pump, depending upon the hydraulic grade line of the system. Alternatively, an adjustable weir or a floating decanter at or just beneath the liquid surface can be used. As with the fixed mounted pipe, discharge from the weir can be regulated by an automatic valve or a pump. The time dedicated to DRAW can range from five percent to more than 30 percent of the total cycle time. The time in DRAW, however, cannot be overly extended because of possible problems with sludge discharge.

Idle. After DRAW the tank is ready to receive additional wastewater. The period between DRAW and FILL is termed IDLE. This time can be used effectively. As Figure 3 shows, sludge can be wasted during IDLE. The frequency of sludge wasting can range between once each cycle to once every two to three months depending upon system design. Aeration and/or mixing may or may not be provided during IDLE, depending upon whether aerobic digestion or denitrification is desired.

DEVELOPMENTAL PROGRAM

The program was conducted in three phases. The first phase included multiple bench scale simulations of the SBR to evaluate the feasibility of the system, define design parameters, and project optimal operating strategies for the full-scale system. The second phase included the design, construction and shakedown of the full-scale system. The final phase included the six-month test program during which time the full-scale system's performance was monitored under a variety of planned and unplanned operating conditions. A summary of the key findings from each phase is presented in turn.

Bench-Scale Test Phase

The objectives of the first phase of the program were to conduct bench-scale simulations of the SBR to evaluate the system on the actual wastestreams the full-scale system would treat, determine optimal treatment strategies for the full-scale system, and subsequently, to determine design criteria for the full-scale system. Accordingly, four bench-scale SBR's were constructed in the laboratory and operated over an initial period of two months.

Reactor Design. Each reactor was a 10-liter polycarbonate container which was drilled and ported to allow gravity discharge of process effluent. Air was supplied to the reactor by an air compressor and controlled through automatic solenoids. Additional mixing was provided by magnetic stirrers. Feed was supplied to the reactors through peristaltic pumps and adjusted for appropriate volumes depending on which of four treatment strategies was employed. All pumping, aeration, agitation and discharge functions were automatically sequenced through the use of laboratory timers.

All four reactors were operated at room temperature, which ranged between 24-26°C. Feed was obtained from the pre-carbon pH adjustment tank (Tank L-8, see Figure 2) initially in two-week supplies, and later on a daily basis.

Operating Strategies. Four reactor operating strategies were designed; they are labelled A, B, C and D. Details on the use of the four strategies are summarized in Tables 2 and 3. All reactors were seeded with activated sludge obtained from the Niagara County Sewer District No. 1 Treatment Plant and operated under Strategy A for about three weeks.

Table 2
Reactor Strategies

Strategy	Cycles Per Day	Cycle Time (h)	Feed Volume Per Cycle (l)	Total Volume Per Day (l)	Retention Time (d)
A	1	24	1	1	10
B	1	24	2	2	5
C	2	12	2	4	2.5
D	2	12	4	8	1.25

Table 3
Reactor Cycle Composite*

Fill:	10 hours
React:	10 hours
Settle:	2 hours
Draw/Idle:	2 hours

* Twelve-hour cycles were exactly one-half the above.

Each reactor was arbitrarily labeled 1,2,3 or 4. The operating strategies used during the last 62 days of the study period discussed herein are provided in Figure 4. Typical variations in the characteristics of selected influent parameters are shown in Table 4.

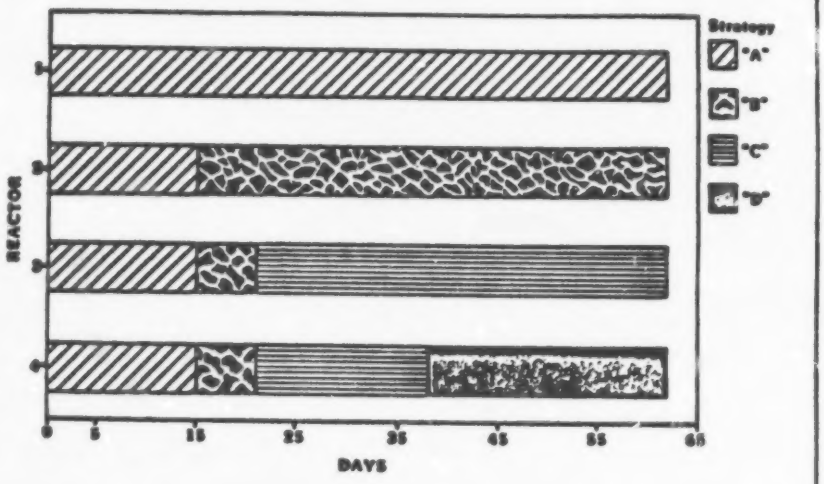

FIG. 4 . REACTOR OPERATING STRATEGIES

Table 4
Influent Characteristics*

pH:	7.5 - 8.2
Phenol:	20.4 - 44.4
Total Solids:	22,000 - 32,000
Total Organic Carbon:	1,100 - 1,500
Ammonia:	200 - 300
Total Phosphorus:	1.8 - 3.8
Cu:	0.1 - 1.5
Ni:	0.7 - 1.2
Ba:	5 - 100
Zn:	0.1 - 0.3

* All results except pH in mg/l

Performance data for each of the four reactors are summarized in Table 5 for percent removal of Total Organic Carbon (TOC) and phenol. Effluent suspended solids (SS) concentrations as well as reactor Mixed Liquor Suspended Solids (MLSS), Mixed Liquor Volatile Suspended Solids (MLVSS) and Sludge Volume Index (SVI) are also reported in this table. All values are based on the average of weekly averages and are listed only for the final treatment strategy used for each reactor. For reactors 1 and 2, values for the first two weeks of operation are not included. Weekly averages of effluent TOC concentrations for each operating strategy are shown in Figure 5.

Table 5
Performance Data

Reactor Number	1	2	3	4
Final Treatment Strategy	A	B	C	D
Weeks at Final Strategy	7	7	6	3
Influent TOC, mg/l	1440	1440	1480	1570
Effluent TOC, mg/l	280(16)*	300(15)	360(13)	710(7)
TOC DEGRADED	81%	79%	76%	55%
Influent Phenol, mg/l	39.5	39.5	42.9	52.8
Effluent Phenol, mg/l	0.3(10)	0.3(12)	1.0(16)	1.7(8)
PHENOL DEGRADED	99.2%	99.2%	97.7%	96.8%
MLSS, mg/l	3200(14)	4300(14)	5100(14)	6900(7)
MLVSS, mg/l	2300 (6)	3200 (6)	3400 (7)	4000(4)
EFFLUENT SS, mg/l	120 (9)	150 (9)	120 (9)	90 (5)
SVI, ml/g	30 (6)	25 (6)	30 (6)	25 (3)

*The values in parentheses represent the number of data points used to calculate the indicated parameter average.

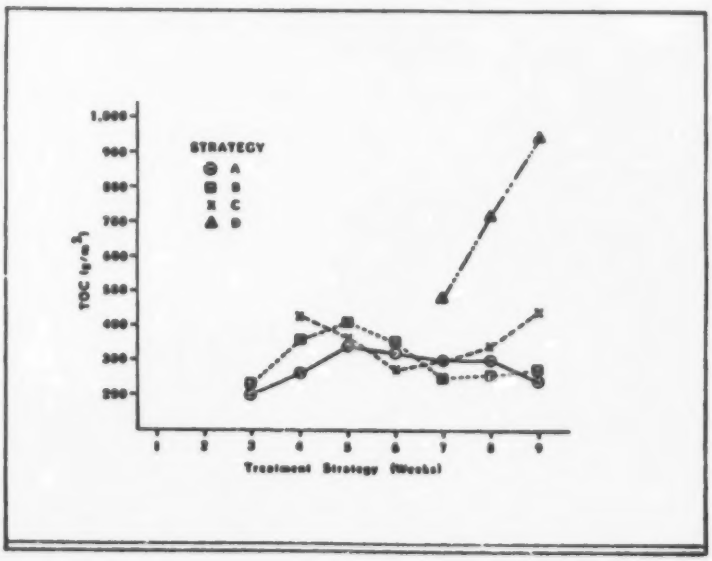

FIG. 5 . WEEKLY AVERAGES OF EFFLUENT TOC FOR EACH OPERATING STRATEGY

Both phenol and TOC degradation improved with increased retention time as seen in Table 5. Based on a proposed volume of 1890 m^3 for the full-scale SBR, the three treatment strategies most suitable for implementation at CECOS would be A,B, and C. For these strategies, TOC and phenol effluent limitations of 1000 mg/l and 2.4 mg/l, respectively (based on an expected average flow rate of 300 m^3/day would be satisfied.

The decline in performance shown in Figure 5 for the 1.25-day retention time of Strategy D is quite dramatic. Additional studies indicated that the time for REACT was not sufficient to completely degrade the organics in this system. Elevated TOC values for Strategies B, C, and D during the final week of operation may have been due, in part, tc a 40 percent increase in influent TOC.

In order to further assess the overall reaction potential of organism systems developed for the different operating strategies, oxygen uptake rates were determined throughout FILL and REACT periods for Strategies A, C and D. This was accomplished by removing mixed liquor samples from the reactor and placing them in a closed, 135-ml vessel and monitoring the change in dissolved oxygen (D.O.) with time. Unit oxygen uptake rates were determined by dividing the oxygen uptake rates by the MLVSS concentration in kg/m^3. Results from these studies are summarized in Tables 6, 7, and 8.

Table 6
Oxygen Uptake Rate Study: Strategy A

Cycle Time (h)	Reactor D.O. (mg/l)	Oxygen Uptake Rate (mg/l-h)	Unit Oxygen Uptake (g/kg-hr)	TOC (mg/l)
Fill Period:				
0.0	-	-	-	250
0.2	5.5	14	4.8	280
1.2	6.5	15	5.0	-
2.5	6.5	15	5.0	-
4.6	6.6	15	4.9	270
7.0	6.4	14	4.7	-
React Period:				
10.2	6.3	13	4.4	230
11.2	6.5	11	3.6	-
12.3	6.4	11	3.6	-
13.3	6.4	9	2.9	-
14.3	6.5	8	2.7	260
23.0*	6.8	6	2.0	270

* React extended three hours to determine impact of additional aeration

Table 7
Oxygen Uptake Rate Study: Strategy C

Cycle Time (h)	Reactor D.O. (mg/l)	Oxygen Uptake Rate (mg/l-h)	Unit Oxygen Uptake (g/kg-hr)	TOC (mg/l)
Fill Period:				
0.3	1.8	38	8.5	500
1.3	1.5	65	14.3	330
2.3	1.6	67	14.8	475
3.6	1.1	64	14.3	390
4.9	0.9	60	13.3	310
React Period:				
5.9	4.7	31	6.8	360
7.3	5.3	24	5.2	325
8.5	5.3	22	5.0	300
9.5	5.3	21	4.7	320

Table 8
Oxygen Uptake Rate Study: Strategy D

Cycle Time (h)	Reactor D.O. (mg/l)	Oxygen Uptake Rate (mg/l-h)	Unit Oxygen Uptake (g/kg-hr)	TOC (mg/l)
Fill Period:				
0.0	2.0	-	-	800
0.3	0.8	150	35.7	-
1.1	0.8	200	47.9	-
2.5	0.5	240	56.0	830
3.8	0.6	230	54.0	-
4.9	0.7	220	51.4	870
React Period:				
5.3	0.4	150	35.5	-
6.1	0.7	140	34.3	-
7.3	0.6	130	30.0	860
8.5	0.7	90	21.2	-
9.5	1.1	90	21.0	770
28.6*	-	20	4.3	610

* Sample removed from reactor at end of the react period and aerated for an additional 18.6 hours.

All three studies demonstrated a rapid increase in the oxygen uptake rates at the beginning of the feed cycle, indicating that the influent is readily biodegradable in the SBR. In addition, the two treatment strategies (A and C) likely to be utilized in the full-scale demonstration study gave peak unit oxygen uptake rates well within the capabilities of the full-scale aeration equipment that was ultimately designed.

Additional oxygen uptake rate studies were conducted to determine better the impact of substrate concentration on the rate of oxygen consumption. In these studies, samples of the mixed liquor from reactors operating under Strategies A and C were removed and aerated. 135-ml aliquots of each were spiked with varying amounts of SBR feed wastewater. The TOC of this wastewater was 1430 mg/l and the MLVSS for Strategies A and C were 2000 mg/l and 3200 mg/l, respectively. Results are illustrated in Table 9 and Figure 6.

Table 9
Spiked Oxygen Uptake Rate Studies
Reactor Strategies A and C

Reactor Strategy	Spike Volume (ml)	Oxygen Uptake (mg/l-hr)	Unit Oxygen Uptake (mg/l-h)	Theoretical TOC (mg/l^3)	Change In TOC (mg/l)f
A	0.0	5	2.7	320	-
A	0.5	22	11.1	324	4
A	1.0	48	24.0	328	8
A	4.0	73	36.8	352	32
A	8.0	76	38.2	382	62
C	0.0	14	4.4	340	-
C	0.5	61	18.9	344	4
C	1.0	110	32.4	348	8
C	4.0	160	49.4	371	31
C	8.0	180	56.5	401	61

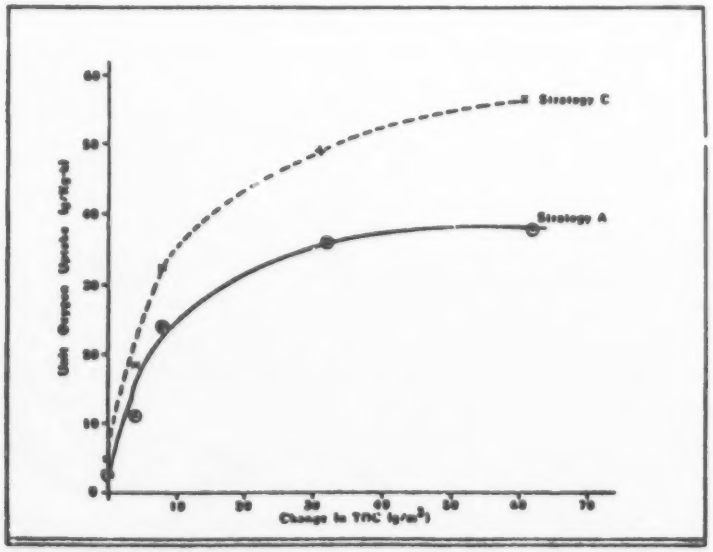

FIG. 6 . UNIT OXYGEN UPTAKE vs. TOC

As the TOC of the mixed liquor was increased, the oxygen uptake rate increased in like fashion. Since increased oxygen uptake is an indicator of biological activity, it follows that the bacteria can increase their overall consumption rate to consume higher concentrations of organic material. This flexibility exhibited by the bacteria allows a unit of this design to treat widely varying volumes and strengths of wastewater.

Additional Studies. Three of the four reactors received supplemental phosphorus in the form of hexametaphosphate and/or phosphonate for a period of approximately three weeks. During this period, no noticeable differences were observed. This implies either that sufficient phosphorus was available in the SBR influent during this three-week period or that phosphorus addition has no noticeable affect upon SBR performance.

During the three-month test period, excessive foaming occurred on occasion. As required, minor amounts of a commercially-available defoaming agent that is normally used at the CECOS Wastewater Treatment Plant was added with immediate improvement.

In order to evaluate a power failure or a significant mechanical problem, one reactor was not operated for 48 hours. TOC measurements were made immediately before and after this period, after which time a normal mode of operation was resumed. No short-term or long-term effects, such as elevated effluent TOC, excessive odor, or flotation of the sludge blanket, were observed.

In order to simulate SBR operation during extended periods of cold weather, as is typical during the winter months, a bench reactor was modified to provide sub-room temperature operating conditions. The temperature of the reactor was dropped slowly through a 12° range (17°-5°) over a course of seven months. The reactor, when compared to an identical unit running at room temperature, showed a lower degradation efficiency for both TOC and phenol concentrations. However, at no time did the effluent from the low-temperature reactor exceed the discharge limits set for these two parameters. The results of this study indicated that a biological treatment system such as the SBR could be used as a viable form of wastewater treatment through periods of cold weather as long as the temperature of the bulk liquid experienced a slow rate of decline.

Full-Scale SBR Facility

As a result of the bench-scale studies, a full-scale demonstration facility was designed. Planned modifications to Phase II of the existing treatment facility are as shown in Figure 7. Major changes involved the construction of a 1890 m^3 SBR, re-routing of wastewater from L-6 to L-8 for pH adjustment, storage of this water in L-7 for treatment in the SBR, and use of L-12 for any additional sedimentation that may be necessary and to serve as a feed tank to the activated carbon system.

The anticipated benefit of these process modifications was a decrease in the TOC loading on the facility's activated carbon beds.

Facility Design and Construction. Facility design was completed in the fall of 1983 and incorporated several key features. The aeration system was sized based upon oxygen uptake studies performed on the bench-scale reactors. The system, designed by Jet-Tech, Inc., was sized to provide three blowers, two primary and one standby. During the FILL phase and early REACT phase of each cycle, two blowers would be utilized to maintain sufficient oxygen to the system. As the oxygen demand decreases, D.O. probes would monitor the increasing oxygen levels in the tank and function to shut down one of the blowers when a single blower would be sufficient to meet the system needs. The aeration system also

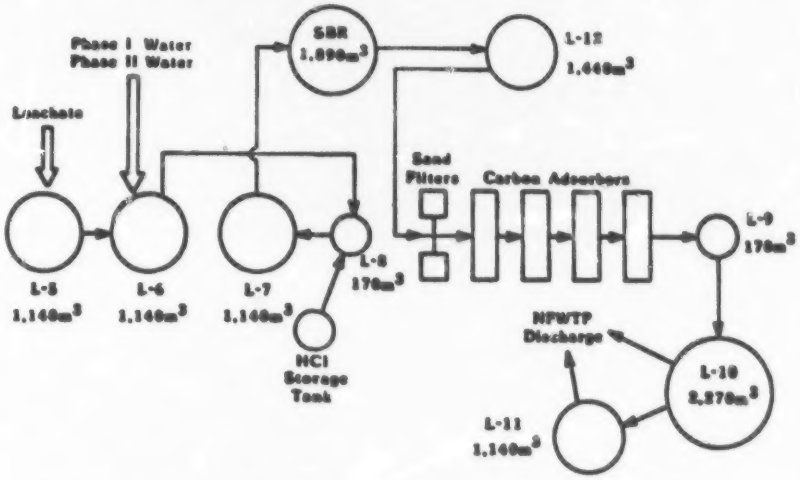

FIG. 7. PHASE II WASTEWATER TREATMENT SYSTEM MODIFIED TO INCLUDE THE SBR

incorporated four recirculation pumps to assist in providing agitation of the tank contents during the FILL and REACT cycles.

Another major design feature was to provide a covered, insulated tank for the system. The insulation allows heat generated by the blowers to be retained in the system and provide for four-season operation.

The 1890 m^3 tank and pumps were sized to allow a daily hydraulic capacity from 0 to 760 m^3/day.

The SBR tank was constructed using a Swiss-patented rolled tank process. This unique method uses two electric crimping machines, the steel guide structure and rollers to join together coils of galvanized steel in a continuous spiral. Coils of steel, each 46 centimeters in width, were rotated around the 21 meter diameter of the tank and crimped together to form the tank wall. When two lifts of the tank had been installed, construction crews then installed the cone-shaped cover of the tank. After this phase was complete, the final rows of steel were installed to complete the tank. Silicone caulking was applied during the crimping process to seal the layers of steel together securely. The height of the completed tank wall was 6.5 meters.

The inside of the SBR tank was sandblasted and painted with an 0.5 millimeter coating of coal tar epoxy. Two hundred feet of fiberglass aeration piping along with four submersible pumps were then installed within the reactor. The jet aeration system, consisting of three rotary positive displacement blowers, supplies oxygen for the process and maintains complete mixing. A floating decanter (also made of fiberglass) was installed at this time as well. The adjoining process control building houses the process control computer as well as the three blowers. The computer is programmed to control all phases of the treatment process, therefore, the system requires minimal monitoring. However, operations personnel routinely monitor the process during its 24-hour treatment mode.

FULL-SCALE SBR OPERATION

Reactor start-up was accomplished over a three-day period ending on June 7, 1984. During this initial period, the reactor was filled with tap water and seeded with activated sludge obtained from the Niagara County Sewer District No. 1 Treatment Plant. Raw wastewater was gradually introduced to the system. The reactor was then operated for a period of six weeks at a one cycle, 225 m^3/day throughput. Each batch cycle consisted of a 10-hour fill period, 10-hour react, 2-hour settle, 0.5-hour draw and 1.5-hour idle period. The daily throughput of 225 m^3/day resulted in an eight-day hydraulic retention time in the reactor.

Figure 8 illustrates that acceptable effluent quality was achieved at the onset of full-scale operation and approached a steady state within three weeks despite a rapid increase in influent TOC and phenol concentrations. This early success resulted in part from dilution effect during the initial few days as the original tank contents were displaced by wastewater. No sludge was wasted during this period and the mixed liquor suspended solids increased from 1,000 mg/l to 2,000 mg/l. Effluent suspended solids remained at 100 ±20 mg/l throughout the period, indicating that the microbial populations achieved good settling characteristics and that the tank decanter was functioning properly.

At the end of this six-week period, the reactor was brought fully on-line and was utilized to meet all of the wastewater treatment needs of the plant. For the next six-week period, the daily batch sizes were varied between 245 and 360 m^3/day, as determined by the operation requirements for that time period. The reactor was maintained on the same treatment strategy of one cycle per day, the feed rate to the system being the primary variable. The percent TOC degraded remained constant through this period at 76 ±3 percent although the effluent phenol concentrations did begin rising midway through the period. This

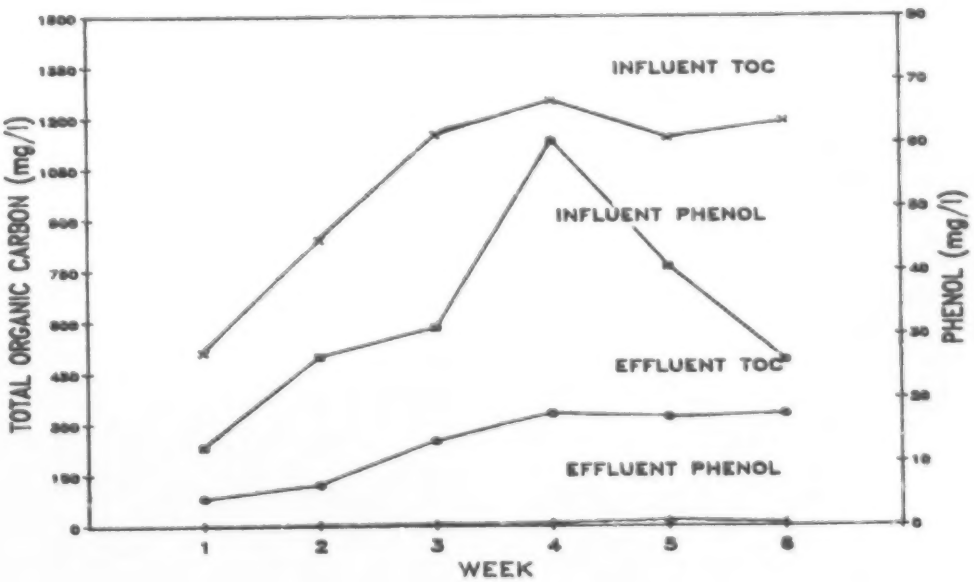

FIGURE 8. SEQUENCING BATCH REACTOR OPERATING DATA SUMMARY – START-UP

increase was attributed to a temperature rise in the tank resulting from transfer of heat from the blowers into the SBR via the air stream. The increase in phenol concentration was noticed as the liquid temperature surpassed 32°C, peaked as the temperature rose to 34°C, and then stabilized. The inability of the organisms to efficiently degrade phenolic materials at higher temperatures provided some insight as to their overall consumption capability. It could be concluded, after considering both full-scale warm operation and bench-scale cold operation, that the bacteria within the reactor probably operate most efficiently within a limited range of temperatures. In general, the overall treatment during this period was quite satisfactory and confidence was gained in the system's capability to treat wastewaters of varied characteristics. A summary of the system's operating data during the period is presented in Figure 9.

With this increased confidence, the system's response to wide variation in influent volume was evaluated. Operating data for this three-week test period are presented in Figure 10. A review of the data indicates that the system can react to large variations in throughput without a major impact on the effluent quality.

This study was interrupted to an upset occurring upstream of the SBR. The upset resulted in high levels of copper in the wastewater. Over a three-day period, the copper levels within the reactor increased from less than 1.0 mg/l to 8.8 mg/l. This accompanied by a sharp reduction in the oxygen uptake rate of the bacteria as depicted in Figure 11. Feed to the SBR was halted for two days while the reactor was aerated. Feed was then slowly reintroduced to the system. The graph demonstrates that the viability of the system recovered as the concentration of copper was reduced. Although the oxygen uptake rates did not return

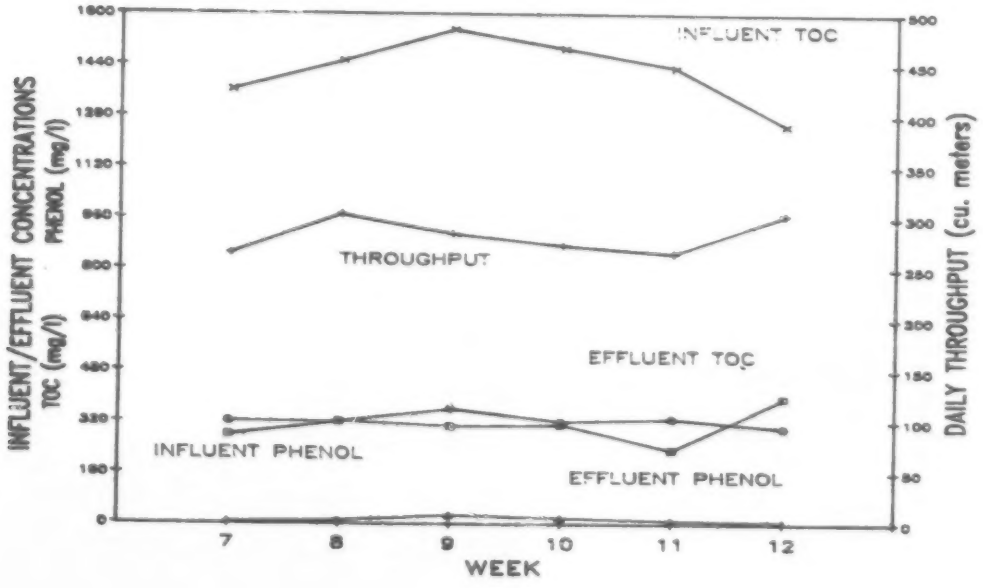

FIGURE 9. SEQUENCING BATCH REACTOR
OPERATING DATA SUMMARY – WEEKS 7–12

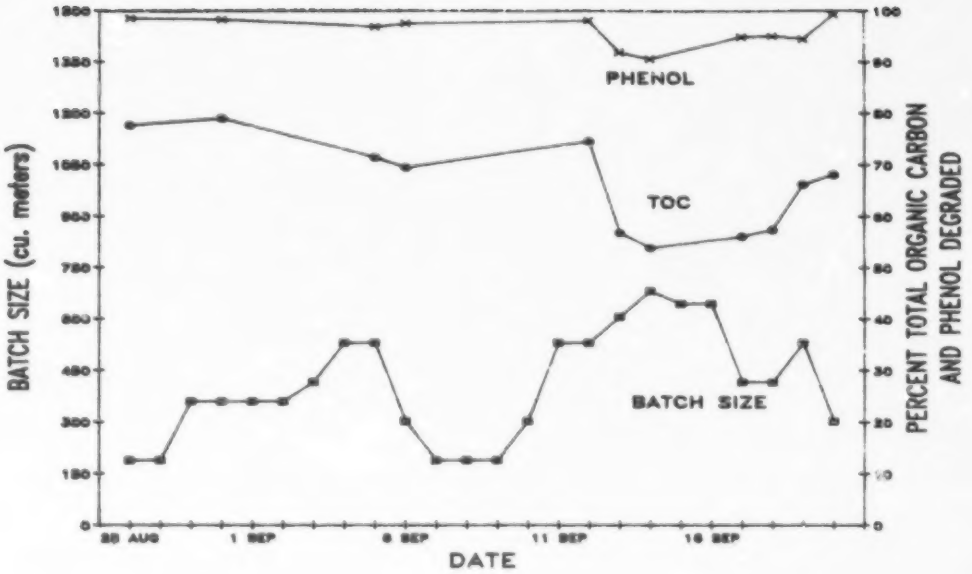

FIGURE 10. SEQUENCING BATCH REACTOR
OPERATING DATA SUMMARY – SEPTEMBER 1984

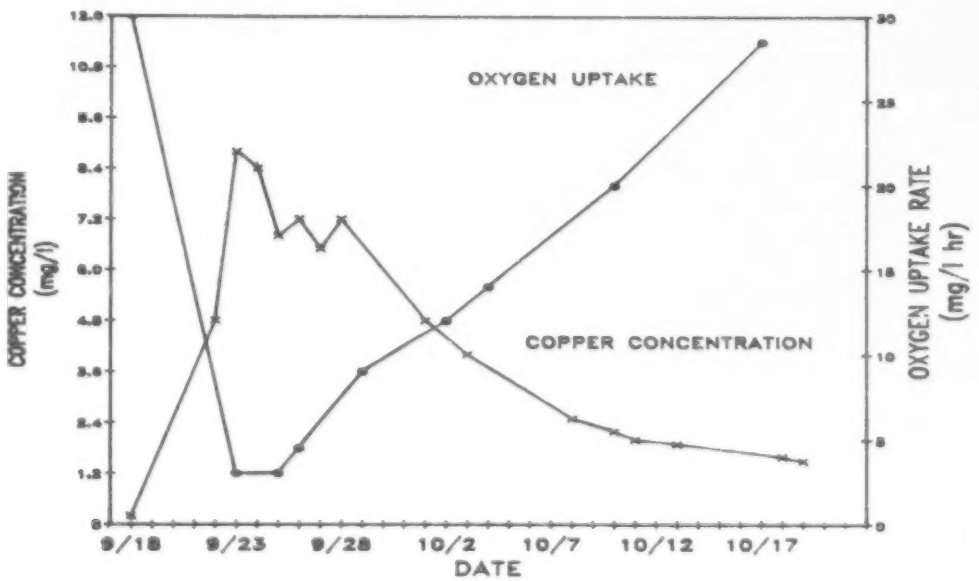

FIGURE 11. SEQUENCING BATCH REACTOR
OXYGEN UPTAKE VS. COPPER CONCENTRATION

to normal for a period of almost 30 days (at which time the copper levels were less than 2.0 mg/l), the mixed liquor TOC and phenol levels remained within acceptable levels throughout the period. During this recovery period, the system was maintained on a one cycle/day treatment strategy with upstream retention capacity utilized to absorb day-to-day variations in hydraulic capacity requirements.

In the sixth month of operations, the treatment strategy was altered to two cycles per day, the duration of each treatment step (i.e., FILL, REACT, etc.) remaining proportional to that applied during one cycle/day operations. During the initial days of operation during this period, the performance of the system paralleled that of the one cycle/day operation. However, after two weeks, a steady decline in system performance was observed (Figure 12). It is believed that this loss in was not a result of the change in treatment strategy, but reflects other influences on the system. During this period, the ambient temperature declined severely and, as the influent and the reactor were not heated, the reactor temperature dropped approximately 10°C over a two-week period. This rapid temperature drop did not allow the biological population sufficient time to acclimate. As can be seen in Figure 12, the TOC removal efficiency of the reactor dropped severely, while the phenol removal rate experienced a less traumatic decline.

This situation was remedied by stopping all flows through the SBR, while simultaneously aerating the reactor for an extended period (8 days). Using this method, the reactor was slowly warmed to a more suitable operating temperature (11-12°C). The reactor was then fed with small quantities of wastewater on a

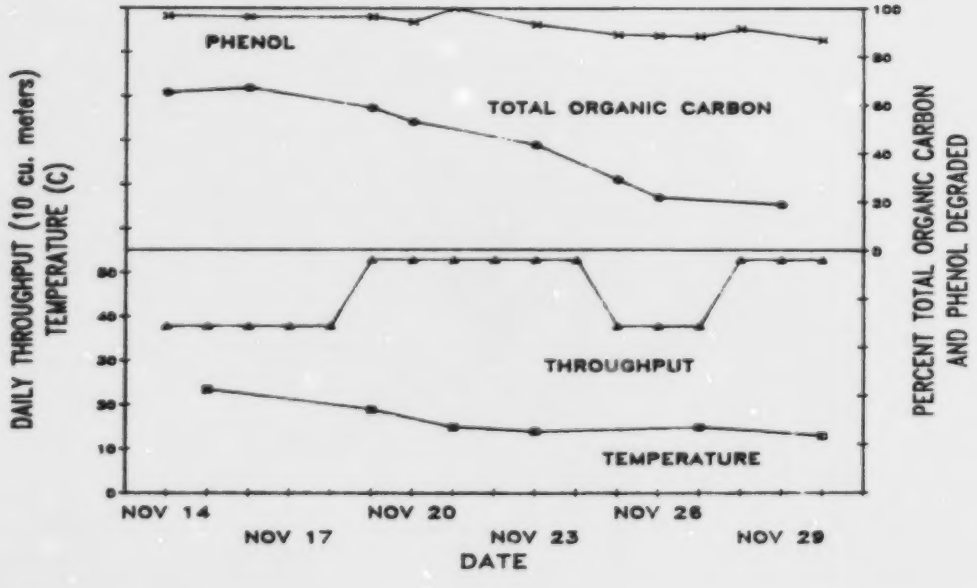

FIGURE 12. SEQUENCING BATCH REACTOR
DATA SUMMARY – STRATEGY B (2 cycles/day)

one cycle/day basis, thereby preventing another large temperature drop. It was found that the reactor once again performed satisfactorily, a fact which pointed out the importance of heat to a biological waste treatment system. Steps are presently being taken to identify a suitable heating method to add to the Niagara Falls installation.

During the six-month period following SBR start-up, a total of only 105 m^3 of sludge containing 3 percent suspended solids was wasted from the SBR. The average mixed liquor suspended solids over the period was 3440 mg/l vs. 2020 mg/l mixed liquor volatile suspended solids. The ratio of MLSS to MLVSS indicates that a large percentage of the solids buildup was other than biomass.

The average sludge volume index (SVI) over the period was 42 ml/g, a value indicative of the excellent settling characteristics of the sludge. The low SVI results from the high available oxygen and nutrients as well as the selective retention of a biopopulation with good settling characteristics.

SYSTEM OPERATION AND DESIGN ANALYSIS

In general, the system operated as designed throughout the six-month post start-up period. No major structural design flaws were identified, although many smaller problems were experienced with the instrumentation and electrical control systems.

The aeration system consisting of three blowers, a jet aeration system and four recirculating pumps performed well. Originally designed so that one or two blowers would be cycled on, with a third in reserve, it was found that a single blower provided adequate airflow to the vessel at all times during the treatment cycle.

The floating decanter performed well as evidenced by the low level of suspended solids in the effluent. With the intakes located six inches below the surface, it did not appear as if surface scum was being pulled into the discharge.

Maintenance of the system is routine and requires only a minimal allotment of manpower. The primary maintenance consists of weekly performance checks on the blowers and pumps with adjustments as necessary. The blowers are checked weekly with an oil change performed every 500 hours. Records of the times of operation of each piece of equipment are readily derived from daily printouts from the computer control system.

ECONOMIC ANALYSIS

Operation of the Sequencing Batch Reactor has, to date, resulted in only minimal costs which have been more than offset by cost savings resulting from the improved treatment of wastewaters.

Prior to installation of the SBR, the cost incurred for the regeneration of activated carbon was the major operating expense at the wastewater treatment plant. The operation of the SBR has significantly reduced the plant's reliance on carbon for organic contaminant removal.

A utility savings was also incurred. This was achieved through the decreased usage of electrical power due to the reduction in both pre- and post-carbon aeration.

A third area in which operating costs were reduced was in the surcharge paid to the Niagara Falls POTW for discharge of both TOC and suspended solids. Operation of the SBR has reduced overall payments made for these parameters by over 40 percent.

Costs incurred through the addition of the SBR to CECOS' wastewater treatment operation are attributable to capital depreciation as well as increased maintenance costs, which were taken to be 50 percent of the depreciation value.

A cash flow analysis performed for the project provides a return on capital investment of 12.1 percent for the project, with the payback period (excluding interest) being four years.

In addition to the quantifiable benefits, the SBR also had an impact on the operation of the entire system. Prior to installation of the SBR, TOC reduction was performed by upon the carbon system and bioactivity in the series of aerated tanks. Reduction of TOC to the discharge level of 1000 mg/l required extended residence times in the tanks or had to be accomplished with carbon. The SBR has provided superior treatment at a minimal residence time so that the overall throughput capacity of the plant has been improved in addition to effluent quality.

CONCLUSIONS

The Sequencing Batch Reactor performed exceptionally well over the six-month study period. Start-up was smooth and rapid, especially in light of the complex and varied nature of the influent. The system is able to react to wide variations in nutrient and hydraulic loadings while producing an acceptable effluent quality.

As with any biological system, the reactor is sensitive to the rapid introduction of biostatic or toxic substances. In an individual industrial setting wherein the influent quality is well characterized and consistent, this should not be a major consideration. However, a commercial treatment facility wishing to implement SBR technology must set up a program of quality control and chemical equalization on streams entering the reactor so that no potentially harmful or persistent substances enter it. Although CECOS performs routine monitoring functions on wastewaters entering this biological treatment system and implements pH adjustment to the reactor influent, several upsets of the SBR due to increased levels of certain constituents in the mixed liquor have indicated the need for a more stringent quality control procedure.

Operating costs and operator attention have proven to be minimal, consisting primarily of routine process control analysis and weekly maintenance checks.

It appears as if the system is sensitive to rapid negative temperature variations indicating that supplemental heat may be required during the transition to cold weather conditions to allow the biological populations to acclimate. Instances of high mixed liquor temperature have also proved to be troublesome, although the magnitude of the upset due to this occurrence is significantly smaller than the upset produced by cold weather conditions. During routine operations, however, the transfer of heat from the blowers provides an average 10°C temperature differential between the influent and tank contents.

In short, operation of the SBR has been demonstrated to offer economic and energy-saving advantages while providing good effluent quality on a complex wastestream.

CHEMICAL DESTRUCTION OF PCBS

Dr. Claude E. Terry
Vice President - Research & Development, PPM Canada, Inc.

BACKGROUND

PPM Canada, Inc. is a waste management firm specializing in polychlorinated biphenyls (PCB) handling, chemical destruction and testing. PPM has offices in Toronto, Regina, Saskatchewan and facilities in Kansas City, Missouri and Atlanta, Georgia. PPM's laboratories are located in Regina and Atlanta and are equipped with the most modern equipment available to measure PCB's and other hazardous contaminants in oil, air, and water.

PPM has developed a process for destroying PCB's chemically. This process lends itself to use either by a mobile decontamination rig, or at our fixed facilities.

The mobile unit underwent its first commercial operation early in November, 1981, in the states. A clean-up was observed by USEPA. Demonstrations were carried out during 1983, 1984, and 1985 for 3 provinces. Analysis by both independent laboratories, Environment Canada (EC) and Ministries of the Environment laboratories indicated that PCBs were reduced to undetectable levels in the oil (functionally defined as <2 PPM.

In August of 1985, PPM Canada demonstrated the process again to EC and MOE, Quebec. At that time PPM treated 299,000 liters of oil containing a variety of levels of PCB. Again, the mobile unit reduced PCBs in the oil to undetectable levels.

Chemical PCB destruction technologies are usually sodium-based processes that dechlorinate the PCB molecule. Although sodium processes are relatively new methods of dealing with PCB disposal, they are a known technology in the chemical industry and used in a variety of other processes. In fact, a sodium process was used for some time in the oil industry to purify virgin transformer oil. The process was later replaced by less expensive sulfuric acid, solvent extraction and hydrogenation processes. The first semi-commercial sodium PCB destruction process was proposed by Goodyear. Goodyear did not commercialize the process, but it made the technology available to any firm interested in commercializing the technology. The initial "Goodyear Process" had serious economic and safety problems associated with it. The most serious problem was the use of a highly flammable solvent, tetrahydrofuran, to dissolve the metallic sodium. Independently, several firms, including PPM Canada, Inc. have developed their own proprietary processes.

An advantage of chemical treatment using the PPM process rather than incineration is that the process avoids conditions forming highly toxic chlorinated and non-chlorinated dibenzofurans and dibenzodioxins. These materials require oxygen and heat for their formation. However, the PPM Canada, Inc. process is done in an oxygen-free atmosphere and at ambient temperature. Moreover, the sodium reagent chemically destroys any chlorinated dioxins or furans present, so that these

compounds are avoided. The PPMC process has no emissions or effluent other than salts and a high molecularupt 11 weight polymer, allowing the process to be used at any location safely.

THE PPM PROCESS

The PPM process was independently developed to meet three important criteria:

1. It must be safe and simply operated in the field,
2. It must produce an acceptable product (i.e., transformer oil, etc.), and
3. It must be economical.

For simplicity and safety, the PPM Canada process operates at ambient temperature and does not use flammable solvents. The reducing agent used in the PPM process is a highly complex organo-sodium reagent. Due to proprietary consideration, the exact nature of the agent cannot be disclosed. The reagent is air and water sensitive and therefore the process is blanketed with nitrogen. The process can tolerate small amounts of water, but every effort is made to minimize water levels. The reagent reacts immediately with PCBs and chlorinated hydrocarbons, forming sodium chloride and a polyphenylene polymer.

Transformer oil is a complex blend of organic materials. To determine the reusability of transformer oil, the reaction of the organo-sodium reagent with various components must be examined. Chemically, the sodium reagent is a potent reducing agent and produces reactions similar to the hydrogenation step used in transformer oil refineries.

The sodium reagent immediately reacts with inhibitors, acids, thiols, and chlorides, forming the appropriate sodium salts. These materials are then present in the oil as an insoluble sludge. This solid sludge is composed of a variety of reaction materials and products and includes:polyphenylene, unreacted reagent, NaCl, NaOH, NaOR (inhibitor) and NaO_2R (acids).

After complete destruction of all PCBs, the reagent has also converted inhibitors and acids into insoluble sludge. The polyaromatic nature of the oil is either unchanged or slightly increased due to the coupling nature of the reagent. The increase is insignificant, but should improve the properties of the oil.

To reuse the oil as transformer oil, the above described sludge is removed. After clean-up, sodium levels in the oil have been reduced to undetectable levels and the oil passes or exceeds transformer oil specifications.

To this point, PPM Canada has been certified by Environment Canada to operate decontamination units for PCB destruction. Typically, PPM Canada conducts a demonstration for the provincial MOE at the first clean-up project in that Province. Currently, PPM Canada has a fully operational fixed facility in Saskatchewan, which includes a laboratory equipped to perform all tests related to utility-generated oils, PCB levels and upgrading. In addition, PPM Canada is currently or has recently operated the mobile PCB destruction unit in Quebec and British Columbia.

MOBILE UNIT

PPM has incorporated the sodium process into a mobile decontamination unit. The unit is on a trailer towed to the site where the hazardous material is stored. By taking the unit to the site, problems associated with transportation, handling and public and worker exposure of the contaminated oil are greatly reduced. The need for a permanent disposal site is also eliminated by cleaning the oil so that it can be reused.

TRAILER

The unit has been constructed in a forty foot trailer. All lines and equipment on the trailer are within a large spill pan. The pan holds approximately 1.200 gallons which is more than the combined volume of all tanks on the unit.

The trailer is connected to the holding tank using two-inch chemical transfer lines. The lines are fitted with male/female quick disconnects. During storage and transportation, all of these lines are plugged or capped to prevent spills. Drip pans are placed under all connections. Areas leading to sewers or open water are diked. Valves are opened slowly and all connections are checked for leaks.

SUPPORT VAN

Chemicals, laboratory equipment, water filters and miscellaneous equipment and tools are brought to the site in a twenty foot enclosed panel truck.

CHEMICAL DECONTAMINATION

The PPM Chemical Process consists of three parts: Pretreatment, Decontamination and Clarification. In the Pretreatment portion of the process, water is reduced to acceptable levels by draining the water off the bottom of the tank and using water filters. In the second step, Decontamination, PCBs are destroyed. PCBs in the oil are reduced to undetectable levels. After PCB destruction, the sludge and solids in the oil are removed using a variety of filters.

PRETREATMENT

In the first step of the process the oil is pretreated to remove water, air and a variety of impurities that interfere with the decomtamination.

DECONTAMINATION

After pretreatment the oil is decontaminated. The sodium reagent is added directly to the oil. The amount of reagent added is determined before clean-up by sampling the oil and running laboratory tests to determine PCB, chlorinated hydrocarbon, sulfur and other impurity levels. As the PCBs

react, they are monitored on-site with a gas chromatograph (GC). Reaction is rapid as PCB levels are reduced to undetectable levels. Because PPM tests the oil on-site, the destruction of the PCBs in the oil is guaranteed and PPM does not leave the site until total destruction has occurred.

CLARIFICATION

After decontamination the oil is cleaned of salts and solids in the separator. During this stage, small amounts of water are added to destroy excess reagent and to assist in the separation of the byproducts. The solids, salts and small amounts of water solution of sodium hydroxide are removed in this step. The volume of waste removed is a minimal amount of the original volume (usually less that 2 percent of that volume).

The oil leaving the unit is measured for PCBs, which should be below detection limits. If the level is not below 2 ppm, the oil is retreated. At this point the oil is deregulated, and the owner can reuse the oil.

WASTE STREAMS

Prior to treatment the oil is inspected, and any free water held at the bottom of the tank is drained and disposed according to regulations.

During operation, clothing, rags and disposable equipment that come in contact with PCB-contaminated oil are placed in a container and disposed as necessary for PCB-contaminated materials.

The process itself produces solids and small amounts of sludge and aqueous waste that are removed from the process and disposed according to regulation.

The process does not produce any emissions. There are no discharges into the environment. This makes the PPM process inherently safer than the disposal options of landfilling or incineration. The PPM process can be performed at any location without fear of discharges into the environment.

PROCESS SAFETY

The PPM process is designed for worker and environmental safety. The process itself operates at room temperature and does not use flammable solvents. Equipment construction conforms to industrial safety codes, and equipment hazards are minimized. The equipment is blanketed with nitrogen to avoid reaction side products and to eliminate fire hazards.

Employees are trained in process controls and operational safety. Each unit is operated by qualified personnel. In general, worker exposure to PCB oil is minimized and, under normal operating conditions, should never occur. This is because the PPM process is a closed-system process. Once the PPM mobile unit has been connected to the souce of contaminated oil, all contaminated material is confined to the PPM unit and the

original container. At the end of the PPM process, the oil, the original container, and the PPM unit have all been decontaminated. Each unit contains spill clean-up equipment, and necessary work protection clothing including gloves, goggles, and full-body garments.

On-site fire extinguishers and sodium carbonate are located near the unit for fire protection. An oil absorbant is also available for minor spills and clean-up.

SAMPLING AND ANALYSIS

Prior to treatment, the storage site is inspected by PPM, Inc. personnel. The inspection team examines the oil storage layout to look for potential problems and to evaluate the safety of the site. During this visit, the oil is sampled and carefully examined by PPM's laboratory to determine the amount of materials needed to clean the oil.

When the mobile unit arrives at the site, the oil is again analyzed for PCB. PPM uses an AID portable gas chromatograph (GC) for site work. As the oil is treated, it is continually monitored for PCBs by the on-site GC. PCB levels are usually undectable and at least less than 2 ppm as required. The PCB analytical technique is an approved EPA method.

SUMMARY

In summary, PPMC's growth in Canada has been relatively rapid. The Sasketchewan laboratory is now one of the major oil testing labs in Canada. PPMC, has detoxified over 640,000 liters of oils for a variety of customers in three provinces.

CHEMICAL DESTRUCTION OF PCBS

Dr. Claude E. Terry
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Polychlorinated biphenyls (PCBs) have been shown to be biocidal and to bioaccummulate. The stability and inert nature of these compounds which led to widespread use, particularly in electrical equipment now makes the compounds a bothersome problem. During the past decade most industrial countries have moved to proscribe the use of PCBs and to initiate disposal of existing supplies.

In Canada, while use is proscribed, disposal is very difficult, since incineration and landfilling, two usual methods for disposal of wastes, are essentially proscribed for PCBs.

For the past two years, PPM Canada, Inc. has been operating mobile units employing a proprietary chemical using metallic sodium as a reducing agent, to successfully destroy PCBs, reducing levels in oil to less than 2 ppm. PPM Canada's process has been demonstrated in several provinces and for Environment Canada and several Ministries of the Environment. A fixed facility in Regina (including a fully equipped laboratory) allows PPM Canada to provide the full complement of PCB destruction capabilities to large or small generators.

Currently, PPM Canada is at the commercial stage-up phase in PCB contaminated dirt stripping via solvents.

TITRE: **GESTION DES SITES DE DECHETS, APPORT DE LA TELEDETECTION ET DES AUTRES METHODES D'INVESTIGATION**

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RESUME

La préoccupation grandissante concernant l'étude des sites de déchets a conduit la firme Aménatech inc. à s'impliquer dans l'étude des sites de disposition de déchets solides. Trois études différentes ont été effectuées en 1984-1985 ou sont en voie de réalisation. Ces trois études concernaient des sites localisés dans la région de Montréal. la première étude implique l'analyse spatiale de sites de déchets au moyen de la télédétection. La seconde concerne la caractérisation physico-chimique et bactériologique de l'eau, puis leur impact éventuel sur la santé publique et sur l'environnement. La dernière, s'applique à l'étude des bio-gaz sur un futur site de construction. La réalisation de ces trois études permet aux auteurs de proposer une méthode intégrée pour l'analyse des sites de disposition des sites de déchets.

1.0 INTRODUCTION

Ces dernières années ont connu au Québec et au Canada une préoccupation grandissante en ce qui a trait à l'étude des sites de disposition de déchets. Des traces évidentes de polluants dans l'environnement forcent les intervenants à trouver des solutions rapides et efficaces pour contrer, ou minimiser l'impact de ces sites sur l'environnement.

Des études réalisées notamment pour le Service de Protection de l'Environnement (SPE) de Environnement Canada et pour l'entreprise privée, ont permi d'accroître notre connaissance générale des sites de déchets solides, de développer et de préciser certaines techniques d'investigation. Notre contribution s'applique à trois principales activités. Il s'agit: d'une analyse spatiale par télédétection des sites et de leur environnement, de la caractérisation physico-chimique de la qualité de l'eau et des indicateurs de pollution puis, d'une caractérisation des gaz et du milieu dans lequel il évolue.

Enfin, pour les études de caractérisation des sites de dispositions de déchets solides, nous proposons une méthode intégrée pour l'investigation des sites.

2.0 PROBLEMATIQUE

A ce jour, au Québec, les programmes d'intervention du SPE et du Ministère de l'Environnement du Québec ont franchi l'étape des inventaires des sites et d'une sélection de certains sites où l'intervention est prioritaire. Pendant ce temps, quelques sites seulement furent l'objet d'une réhabilitation en raison de l'urgence d'intervenir pour limiter les dégâts sur l'environnement.

L'avancement actuel de ces programmes gouvernementaux démontre que ce champs d'étude est encore relativement jeune. Ainsi, il existe aujourd'hui aucune définition claire de ce qu'est un site de disposition de déchets solides au Canada, car le nombre limité d'études ne permet pas d'établir les paramètres généraux caractéristiques des sites de déchets pour une région donnée.

Actuellement, les méthodes traditionnelles d'étude des sites de déchets consistent généralement à localiser des forages ou des sondages sur le terrain. Ceux-ci sont localisés en fonction des données historiques souvent peu étoffées ou même de façon intuitive ou aléatoire. En conséquence l'échantillonnage et les résultats d'analyse ne reflètent pas nécessairement les conditions du milieu.

Dans ce contexte, une investigation valable des sites doit permettre d'obtenir le maximum de renseignements sur la délimitation précise du périmètre du site, la composition, le contexte géomorphologique et hydrogéologique du milieu, les conditions locales favorisant la production de lixiviat et la sensibilité du milieu environnemental.

En conséquence, il apparaît donc nécessaire de mettre au point des outils d'analyse permettant d'obtenir le maximum d'information concernant le site et son milieu environnant.

3.0 CARACTERISTIQUES GENERALES DES SITES DE DECHETS

Il existe très peu de données statistiques sur la nature des déchets qui ont été observés dans les sites de disposition. Il est cependant possible de distinguer 2 principaux types de déchets. Il s'agit de déchets domestiques et industriels. Les débris de

construction ou d'excavation sont quelques fois rencontrés et ont souvent servi comme couche de remblaiement.

La composition des déchets domestiques a travers le Canada est relativement homogène. Elle est sans doute liée aux habitudes de consommation qui semble à peu près identique sur l'ensemble du Canada. Les principaux composants qui forment les déchets domestiques sont: les papiers, la matière putrisible, le verre, les métaux ferreux et les plastiques. De ces principaux constituants, il est intéressant de noter la proportion d'environ 6% pour les métaux ferreux et de 21% de matière organique (Environnement Canada 1979). Ces deux types de constituants ont une incidence sur la différentiation par certains capteurs des types de déchets entre eux (domestique et industriel) et avec le terrain naturel.

La température à l'intérieur d'un site est également un paramètre important puisqu'il régit la période d'activité d'un site. A son tour, cette dernière est étroitement liée à la période de production des gaz à l'intérieur du site. Les températures à la surface des sites peuvent être de 15 à 20% plus élevées que celles des sols naturels environnants (flower et Al., 1977). Les anciens sites dégagent peu ou pas de chaleur. Cependant au site de l'ADACport près de Montréal des profils thermiques de 5 m de profondeur ont démontré que le site, vieux de 20 ans, était encore actif (Aménatech inc., 1984). Cette période d'activité commence au début de juin et se termine à la mi-septembre ou à la fin de septembre dans le cas d'un mois exceptionnellement chaud. Dans la zone tempéré, la période d'activité du site coincide avec le réchauffement graduel du sol en saison estivale et suite à un emmagasinement thermique graduel de réchauffement, ce dernier atteint son paroxisme à la fin du mois d'août.

4.0 TELEDICTION: ANALYSE DES SITES

Dans le cadre d'une proposition spontanée parainnée par Environnement Canada, une méthode d'analyse des sites de déchets basée sur la télédétection, a été élaborée (Aménatech inc., 1984, 1985a, 1985b,) et Vincent et al. (1985).

Cinq sites témoins dans la région de Montréal ont été étudiés (tableau 1) Deux survols aéroportés effectués par le Centre Canadien de Télédétection, transportait un capteur DAEDALUS DS-1260 et une caméra métrique. Ces capteurs permettent d'obtenir respectivement des images numériques et des photos infrarouges couleurs à l'échelle de 1:10 000 (tableau 2).

Tableau 1 : Informations générales sur les sites de déchets à l'étude.

Code d'identification	Nom du site	Localité	Organisme de contrôle
06-05-01	ADACport	Montréal	Environnement Canada
06-01-04	Goodleaf	Kahnawake	Environnement Canada
06-01-05	Patton	Kahnawake	Environnement Canada
06-01-03	Beauvais	Kahnawake	Environnement Canada
-	Ste-Julie de Vercheres.	Ste-Julie	Ministère de l'Environnement du Québec

Les cinq sites de disposition de déchets correspondent à d'anciens dépotoirs qui ne sont plus officiellement en opération, la plupart depuis 1978. La majorité de ces sites sont recouverts d'une mince couche de terre qui a permis à une végétation arbustive de croître d'une façon clairsemée.

Les données de télédétection utilisées dans le cadre de cette étude proviennent de deux sources: les capteurs aéroportés et les relevés géophysiques. Dans le cas de ces derniers, les mesures de conductivité et de magnétisme ont été effectuées selon la méthode de Stephens (1983) avec toutefois un GEONIC EM 34 (au lieu d'un EM 31). Les relevés géophysiques ont été effectués uniquement sur le site de Sainte-Julie. La profondeur d'investigation était de 15 m environ. Les isocontours des données géophysiques ont été numérisées afin de rendre compatible leur superposition aux images numériques issues des capteurs aéroportés.

tableau 2: Les survols de télédétection

Le traitement et l'analyse des données vise à produire des images qui mettent en évidence un ensemble d'informations pertinentes à l'analyse spatiale des sites et de son intéraction sur l'environnement immédiat.

Le traitement numérique d'images a été effectué sur un système DIPIX. Cela consistait à :

- superposer les images thermiques de jour et de nuit
- créer une image d'inertie thermique
- améliorer le contraste
- produire des rehaussements par composantes principales
- transformer les relevés géophysiques en matrice image
- créer des couples stéréoscopiques

TABLEAU 2: Les survols de télédétection

Date	Heure	Capteur	Image produite	Dimension du pixel - échelle approx.	Altitude	Azimut
17-09-84	19:40 GMT 15:40 hre locale	Radiomètre à balayage DAEDALUS DS1260	Canal 3 - bleu Canal 5 - vert Canal 7 - rouge Canal 9 - infrarouge Canal 11 - thermique	3 X 3 m	1 465 m	226°
		Caméra métrique RC-10	Photographies aériennes infrarouge couleur film 2443	1:10 000		
18-09-84	04:45 GMT 00:45 hre Locale	Radiomètre à balayage DAEDALUS DS1260	Canal 11 - thermique	3 X 3 m	1 465 m	226°

Source: Rapport de vol du CCT

L'analyse des données a conduit à définir plusieurs caractéristiques associées à un site de déchets qui sont visibles sur les images de télédétection. Ces paramètres détectables sont énumérés selon l'axe vertical du tableau 3 et sont regroupés selon les aspects généraux, les particularités à la surface ou les impacts sur l'environnement. Ce dernier donne également une évaluation de la performance des images utilisées selon que les paramètres sont fortement (+), moyennement (o) ou faiblement (-) identifiables.

L'analyse du tableau 3 montre que les composés-couleurs et les images rehaussées par composantes principales, sont les plus aptes avec la photo infrarouge couleur, à détecter les divers éléments permettant de bien caractériser un site de déchet et son environnement.

D'autre part, l'intégration des données géophysiques aux données de télédétection permet de définir 5 niveaux d'information lorsqu'on analyse les site d'enfouissement des déchets par télédétection. Il s'agit de la localisation d'un site, de la délimitation du périmètre d'enfouissement, de l'identification des zones sensibles associées aux sites, de la détection d'une dégradation de l'environnement et enfin de l'identification de la nature de certains déchets.

Le tableau 4 énumère les paramètres détectables selon les différents niveaux escomptés en fonction du domaine spectral exploité. Ces informations sont nécessaires à l'utilisateur éventuel qui envisage de se servir de la télédétection pour l'étude préliminaire des sites de déchets. Il est à noter que les coûts d'utilisation de la télédétection augmente en fonction de la complexité des informations anticipées.

La télédétection offre une vue d'ensemble d'un site. Elle permet donc de détecter les conditions environnementales associées à la présence de déchets et d'en estimer les impacts potentiels.

L'étude met donc en évidence le potentiel d'utilisation de cet outil qu'est la télédétection pour l'investigation d'anciens sites d'enfouissement de déchets. Les résultats obtenus sur quelques sites témoins, démontrent clairement l'utilité d'une telle méthode étant donné la quantité d'informations dégagées des documents analysés.

Tableau 3: Détectabilité des paramètres sur les images de télédétection

		B	V	R	IR	Tj	Tg	I	C.C.	C.P.	PHOTO
ASPECT GENERAL	Contraste	♦	♦	♦	♦	♦	o	♦	♦	♦	♦
	Texture	-	o	o	♦	♦	o	o	♦	♦	♦
	Morphologie	-	♦	♦	-	♦	o	o	♦	♦	♦
PARTICULARITES DE LA SURFACE	Infrastructure	♦	♦	♦	o	♦	o	♦	o	o	♦
	Zone dénudée	♦	♦	♦	-	♦	-	o	♦	♦	♦
	Fissure	♦	o	♦	-	♦	-	♦	♦	♦	♦
	Affaissement	o	o	o	♦	-	♦	o	♦	♦	♦
	Ravin	-	-	-	♦	-	♦	o	♦	♦	o
IMPACTS SUR L'ENVIRONNEMENT	Stress sur la végétation	-	-	o	♦	-	♦	-	♦	♦	o
	Qualité de l'eau	-	♦	♦	-	♦	♦	-	♦	♦	o

B - Canal bleu
V - Canal vert
R - Canal rouge
IR - Canal infrarouge
Tj - Thermique de jour
Tg - Thermique de nuit
I - Inertie thermique
C.C. - Composé couleur
C.P. - Composantes principales
Photo - Photo infrarouge couleur

♦ Fortement identifiable
o Moyennement identifiable
- Faiblement identifiable

TABLEAU 4: Critères d'interprétation en fonction du niveau d'information escompté et du domaine spectral

	VISIBLE	PROCHE-INFRAROUGE	THERMIQUE	BASSES FREQUENCES
Localisation d'un site	Tonalité, teinte, Texture Morphologie Infrastructures	Tonalité teinte Texture Morphologie Infrastructures	Tonalité, teinte Texture Morphologie Infrastructures	Valeurs élevées de conductivité
Délimitation du périmètre d'enfouissement	Morphologie	Morphologie Topographie Marais périphériques	Morphologie Marais périphériques	———
Identification des zones sensibles associées au site de déchets	Affleurements des déchets Suintement Fissures	Marais	Affleurements des déchets Suintements Fissures Marais	———
Evaluation de la contamination d'un site sur l'environnement	Stress sur la végétation Qualité de l'eau	Marais Stress sur la végétation	Qualité de l'eau Stress sur la végétation	Valeurs élevées de conductivité
Identification des caractéristiques liées à la nature des déchets	———	———	Limites thermiques sur le site	Combinaison Magnétisme-conductivité Matériau métallique ferre Hydrocarbure Huile et graisse

5.0 EVALUATION DE L'ETAT DE CONTAMINATION DES EAUX SOUTERRAINES ET DE SURFACE

Une étude supplémentaire réalisée au début de la deuxième étape du Programme d'étude des sites de disposition de déchets solides sur les terres fédérales a été réalisée. Quatre sites sont situés sur la réserve indienne de Kahnawake (Beauvais, Goodleaf, Morris et Patton. Les sites de l'ADACport près de Montréal et du Camp Bouchard près de Blainville ont été investigués (Aménatech inc. 1985c).

L'étude a consité a poursuivre les travaux de caractérisation physico-chimique et bactériologique en élargissant la grille de paramètres investiguées aux métaux de trace et aux polluants prioritaires organiques selon U.S.E.P.A. Une évaluation préliminaire des impacts potentiels pour l'environnement et la santé publique ainsi que des recommandations concernant l'approche analytique pour des études hydrogéologiques détaillées des sites ont été formulées. Cette étude visait également à préciser le besoin d'entreprendre les études détaillées des sites dans le cadre de la 3 ième étape du programme fédéral.

Le projet étant limité à un seul campagne d'échantillonnage par site et à un nombre limite de stations d'échantillonnage (4 à 5 stations par site), les priorités d'investigation furent centrées sur une approche favorisant la détection de la présence de contaminants pouvant provenir du lessivage des sites de déchets tout en considérant le besoin d'obtenir des données sur l'état de contamination du milieu environnant.

L'étude renforcissant alors le besoin d'entreprendre des études plus détaillées des sites investigués dans le cadre de la troisième étape du programme fédéral. Les principales recommandations concernent l'approche analytique pour ces études plus détaillées ont été les suivantes:

- Améliorer les techniques d'échantillonnage des eaux souterraines en particulier afin de favoriser une meilleure évaluation des teneurs en métaux de trace (forme dissoute et total extractable) et des composés organiques. Des techniques d'échantillonnage ont été précisées (Aménatech inc. 1985c).
- procéder à des études plus détaillées de l'état de contamination des eaux souterraines et de surface en procédant par étape. La première étape visant à confirmer l'état de contamination du milieu et à utiliser des paramètres indicateurs de pollution pour déterminer la zone de dispersion des produits de lessivage des sites de

déchets. La seconde étape consiste alors à procéder à une caractérisation détaillées des zones les plus affectées.

- utiliser l'approche de caractérisation des sédiments pour évaluer l'état de contamination de plan d'eau.

D'autres recommandations ont été formulées concernant entre autre, l'usage d'une approche écotoxicologique et d'une recherche de données sur les principaux contaminants retrouvés pour supporter l'évaluation des impacts potentiels.

Dans l'ensemble, les piézomètres disponibles pour l'échantillonnage, étaient installés sous le niveau de nappe phréatique à la limite de la couche de déchets. Ceci permettait donc d'évaluer l'état de contamination de la nappe d'eau directement en contact des déchets et par conséquent limite la portée de l'étude en ce qui a trait au degré de contamination de la nappe d'eau souterraine. La caractérisation des sédiments dans les plans d'eau adjacents au site a été une approche originale dans cette étude.

Le choix des paramètres d'analyses fut basé sur un site fournie par Environnement Canada à laquelle nous avons ajoutés des paramètres indicateurs de pollution organique (exemple dénombrement total normalisé), des composés classés prioritaires par U.S.E.P.A., et une détermination de la forme dissoute de métaux, dans l'ensemble cette étude a permis de montrer la présence de contaminants et de substances toxiques de l'environnement et dans la nappe d'eau des sites de déchets. Elle a également contribué à l'identification des impacts potentiellement importants pour la santé publique et l'environnement.

6.0 ETUDE DES GAZ

Une étude des gaz a été réalisée sur un important site de déchets. Le site du futur Centre de Maintenance et d'Entretien de Via-Rail à Montréal. Ce site est contigue à celui de l'ADACport. De nombreuses études ont été réalisées sur ces deux sites. La majorité consiste à des études géotechniques (Labo SM inc. 1985, Lupien, Rosenberg, Journeau et Ass 1984, Mon-Ter-Val 1980) et plus rarement pour l'analyse des gaz (Beak 1979, Foratek 1985 et Aménatech inc. en préparation). L'ensemble de ces études ont fourni plusieurs forages et contribuent largement a une meilleure connaissance de la stratigraphie du site.

Cette étude a été réalisée afin de prévenir tout inconvénient résultant de la présence de gaz lors de la construction et après l'érection du bâtiment (Aménatech en préparation). Le résultat de

cette étude était nécessaire à l'étape de conception du bâtiment afin de construire dès le début des travaux un système d'évacuation des gaz.

L'objectif de l'étude était de:

- déterminer la présence des gaz
- préciser leur composition
- évaluer la production
- évaluer le potentiel de migration dans l'ensemble du site et le long des pieux.

Les travaux ont débuté par la réalisation de 6 forages afin de connaître la stratigraphie et l'implantation de système de captage des gaz. La zone sous le bâtiment principal a été soumise à la compaction dynamique. Deux forages ont été réalisés à l'emplacement du bâtiment principal afin de déterminer la présence de gaz en profondeur. 4 autres forages occupent la zone en périphérie du bâtiment principal.

Deux types de système de captage des gaz ont été installés. Il s'agit des systèmes hors-sol et dans le sol.

Les systèmes de captage hors sol s'apparentent à ceux de York et al 19 . Ils sont installés à la tête de certains pieux. Les détails de conception de ce système apparaissent à la figure 1.

Les systèmes de captage dans le sol sont constitués de trois tubes de 2,45 cm de diamètre. Le premier, le plus profond est le piézomètre qui atteint l'interface du till et des déchets. Les deux autres sont des capteurs de gaz installés à deux niveaux différents au dessus de la nappe d'eau. Chaque niveau est séparé de l'autre par un bouchon de bentonite. La partie réceptrice des gaz est perforée et une lanterne de sable grossier l'enveloppe. La partie supérieure du système de captage est muni d'une valve étanche figure 2.

La procédure d'échantillonnage est la suivante:

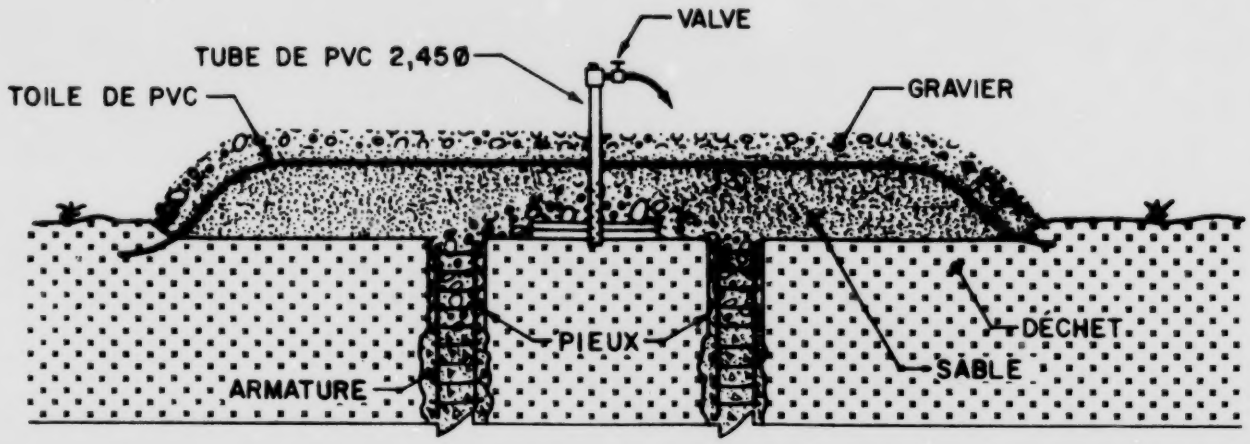
1. mesure de la température en surface
2. mesure de la pressions
3. mesure du débit
4. essais à l'explosimètre
5. échantillonnage des gaz (par pompage)
6. mesure de pression et de débit

La dernière mesure de débit permet de vérifier si les conditions internes de débit et de pression ne sont pas uniquement liées à la différence de conditions entre l'extérieur et l'intérieur du tube de captage. La présence d'un débit persistant indique un contenu appréciable de gaz.

Les résultats préliminaires de l'étude permettent d'avancer certaines constatations. Ainsi, une migration verticale le long des pieux a été interprétée par la présence anormale de CO_2 dans

FIGURE - I

SYSTÈME HORS-SOL DE CAPTAGE DES BIO-GAZ



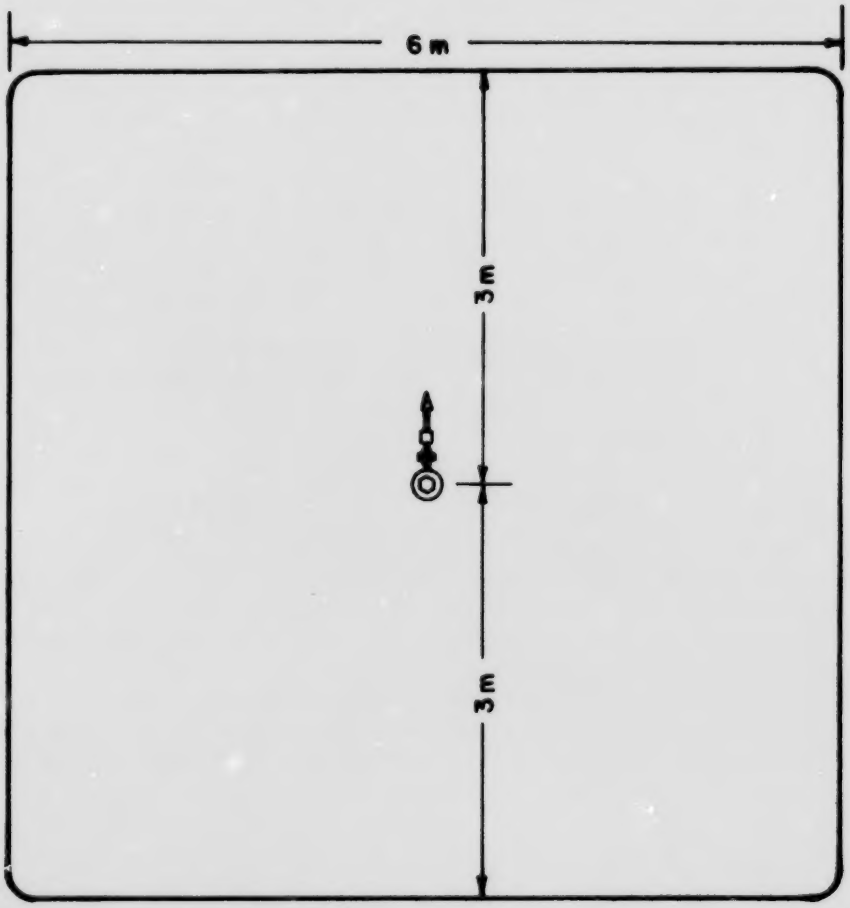
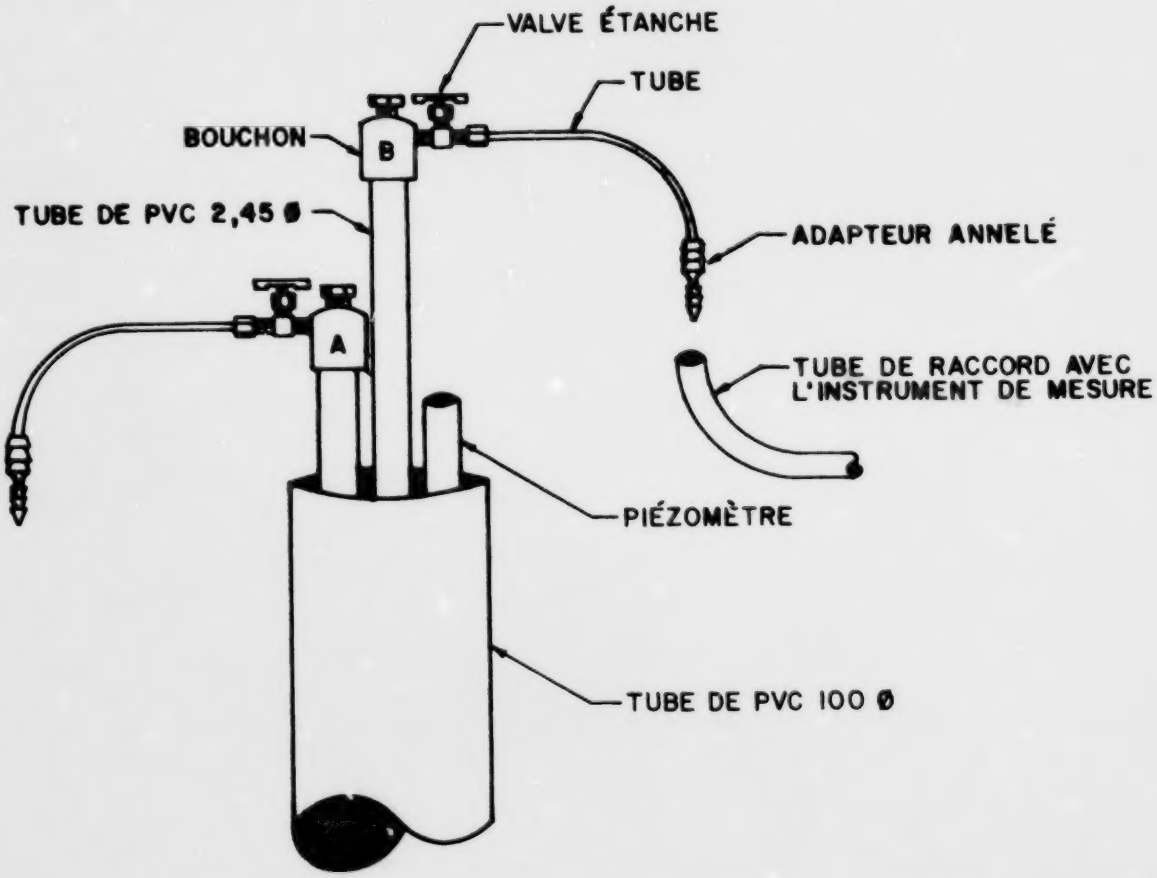


FIGURE - 2

SYSTÈME EN - SOL
DE CAPTAGE DES BIO - GAZ
(AMÉNAGEMENT EN SURFACE)



les systèmes de captage hors-sol. L'absence de CH_4 indique que ce dernier s'est probablement volatilisé en migrant le long de la membrane imperméable et a fuit à travers la couche de remblai poreux.

La présence des gaz a été détectée dans presque tous les forages. Les données du mois de juillet indiquent une décroissance graduelle de la concentration de CH_4 et de CO_2 vers l'est. Les deux forages ayant les concentrations les plus fortes ont également révélé la présence de débit. Ces derniers sont localisés à l'extérieur de la surface soumise à la compaction dynamique. Les débits mesurés étaient de l'ordre de 25 ml/mn

L'étude stratigraphique a permis de constater que la couche de déchets s'amincissait graduellement et de façon importante vers l'est limitant ainsi la possibilité de migration. Cette hypothèse a été confirmée par la présence de deux systèmes de captage en sol. Par contre, les plus fortes concentrations coincident avec la proximité d'une énorme accumulation de déchets domestiques localisée sous la piste de l'ADACport. Ces observations tendent à démontrer la migration possible des gaz en provenance du sud. Il n'est pas exclu toutefois que la production soit uniquement locale.

Enfin, les premières mesures de débit ont débutées au début du mois de juillet. Elles ont été précédées d'une augmentation de la pression. Les débits ont été enregistrés lorsque les pressions ont atteint environ 3 à 4 mm de H_2O. La poursuite des mesures de débits jusqu'à l'hiver nous permettra de vérifier si les débits de gaz persiste après l'arrêt saisonnier de l'activité du site. Elle contribuera également à évaluer si l'effet de piston suite au rehaussement de la nappe phréatique, aura un impact sur l'évolution des débits.

10.0 CONCLUSION

L'ensemble des travaux réalisés sur des sites de la région de Montréal nous permet de proposer une méthode intégrée pour la caractérisation des sites de dispositions des déchets solides.

A l'étape de planification s'inscrit d'abord la méthode d'analyse spatiale des sites de déchets. Elle permet en fournissant des informations pertinentes sur la localisation des secteurs présentant des anomalies spectrales et géophysiques par exemple, de localiser les sites de forages ou les stations d'échantillonnage. L'utilisation de la télédétection favorise une meilleure vision globale des sites et de ses impacts sur son environnement. La télédétection ne se substitue toutefois pas aux

méthodes conventionnelles d'investigation des sites de déchets. Elle assure cependant une meilleure gestion des outils mis à la disposition des intervenants.

Dans une deuxième étape les travaux consistent à faire une étude hydrogéologique et de la qualité de l'eau. L'étude hydrogéologique doit définir les différents paramètres hydrauliques et doit démontrer l'intéraction entre les eaux de surface et de la nappe souterraine. De plus, l'étude hydrogéologique s'accompagnant de nombreux forages, un certain nombre d'entre eux devraient également servir à l'échantillonnage de déchets dans les zones d'anomalies identifiées à l'aide de la télédétection. Après une première série de forages de surface et souterraine. La seconde série de forages et d'échantillonnage permettra de préciser les secteurs plus critiques ou l'étendue du panache de lixiviats.

L'étude hydrogéologique conduit à l'étude de la contamination des eaux souterraines. On tente d'abord de cerner dans la première série de forages, la zone de dispersion en utilisant les paramètres indicateurs inorganiques, organiques et bactériologiques. Par la suite, on compile les caractéristiques de la zone affectée et on élargie l'investigation pour mieux cerner la zone de dispersion des contaminants ou pour préciser les secteurs problématiques. Quant au plan d'eau, une analyse de l'eau et des sédiments est requise. Pour les cours d'eau, un échantillonnage des sédiments de l'amont vers l'aval est aussi nécessaire afin de visualiser l'évolution de la contamination en amont et en aval du site.

L'étude des gaz doit être prévue à l'étape de l'étude hydrogéologique et de la qualité de l'eau puisque les systèmes de captage des gaz devront être installés en même temps que l'installation des piézomètres sur le site de déchets notamment. Cependant cette étude des gaz sera surtout opportune dans le cas d'une construction sur un site, de la proximité d'un milieu urbain ou dans le cas d'un impact des gaz sur la végétation.

Enfin, l'utilisation de la télédétection permettra lors d'un suivi environmental, de visualiser l'évolution spatiale et temporelle de certains impacts sur l'environnement. Elle contribuera également à assurer un suivi après l'instauration de mesures de mitigation ou de correction.

REMERCIEMENT

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manifesté concernant la rédaction de cet article et dans le cadre de plusieurs études portant sur les sites de disposition de déchets dans la région de Montréal.

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PROJET PILOTE: COLLECTE SELECTIVE EN MILIEU URBAIN AU MOYEN D'EQUIPEMENT ADAPTE

Jude Lavoie

Ville de Sherbrooke

BREF HISTORIQUE

La Ville de Sherbrooke, située au coeur des Cantons de l'Est à environ 120 kilomètres de Montréal, compte 80,000 habitants et est vraiment comme dit le slogan: Plus qu'une Ville.

Sherbrooke est l'une des rares villes au Québec à procéder en régie, à l'entière gestion des déchets municipaux. La Ville est divisée en 9 circuits de collectes d'ordures ménagères que les employés de la municipalité parcourent à chaque semaine.

La Ville offre aussi un service de collectes spéciales sept mois par année, de mai à novembre, et toujours la première semaine complète du mois. A cette occasion, les citoyens sont invités à placer en bordure de rue les déchets de façon sélective:

- Fibres
- Verres
- Métaux
- Autres rebus

Les citoyens apprécient grandement l'opportunité qui leur est ainsi donnée de nettoyer les sous-sols, les greniers et les garages. La Ville, de son côté, en tire avantage du fait que les risques d'incendies se trouvent diminués et les quantités de déchets sauvages devant être collectés sur des terrains vacants connaissent une nette diminution.

Le site d'enfouissement sanitaire situé à l'intérieur des limites de la Ville est opéré par cette dernière et reçoit annuellement tout près de 50,000 tonnes métriques de rebut industriel, commercial, institutionnel et domestique.

Quelques précisions sur la collecte des ordures ménagères. Nous sommes, je crois, l'une des dernières villes au Québec à procéder à la collecte des déchets à l'arrière-cour. Un règlement municipal défend, en effet, aux citoyens de déposer les ordures ménagères en bordure de la rue. Les équipes de la Ville vont chercher les déchets à l'arrière des maisons et les apportent au camion. Nous visitons ainsi une moyenne de 700 portes par jour par équipe.

En 1977, le Ministère de l'Environnement du Québec implantait un programme de fermeture des dépotoirs et forçait l'installation des sites d'enfouissement sanitaire.

A cette époque pour la Ville de Sherbrooke, cela revenait à régionaliser notre site d'enfouissement sanitaire, donc, était préjudiciable à la durée de vie du site. La division Salubrité fût chargée de procéder à des études concernant les méthodes d'enfouissement conventionnelles en regard de la durée de vie du site. A l'analyse des opérations du site d'enfouissement sanitaire, nous avons constaté qu'une tonne de déchets entraînait la nécessité d'utiliser 0.8 tonne de sable pour procéder au recouvrement, en conformité avec les règlements en vigueur.

Une étude détaillée sur la disponibilité du sable sur le site même nous laissait voir clairement un manque de sable en l'an 1989. Par conséquent, il devenait impératif de modifier la méthode de gestion des déchets afin d'éviter d'avoir à acheter pour au-delà de 300,000 $ de sable annuellement. Nos coûts d'opérations actuels sont de 250,000 $ par année pour l'enfouissement des quelques 50,000 tonnes métriques de déchets qui sont amenés à notre site.

Le Conseil Municipal mis au courant de ces faits, confiait à la division Salubrité la responsabilité de piloter le plan global de gestion des déchets tant au niveau de la collecte que de la disposition pour la Ville de Sherbrooke. En mars 1984, le plan global fût présenté et accepté par le Conseil Municipal qui adoptait les résolutions suivantes:

- que la Ville de Sherbrooke continue à faire, en régie, l'ensemble de la gestion des déchets solides;

- que la Ville de Sherbrooke tente d'être nommée ville-pilote, pour le Québec, afin de trouver une méthode de collecte sélective des ordures ménagères;

- que la Ville de Sherbrooke procède à l'implantation d'un plan-type d'une usine servant à la revalorisation des matières secondaires.

Le plan ayant été accepté, nous nous sommes tournés vers le Ministère de l'Environnement du Québec et avons demandé une subvention de 40,000 $, à laquelle la Ville a ajouté 120,000 $, afin de procéder au développement d'une boîte de camion spéciale qui permettrait, à la fois, la collecte des ordures ménagères et des matières recyclables, autrement dit, des ressources secondaires. La conception et la réalisation de ce projet est sous la gouverne d'un comité formé de représentants de la Ville de Sherbrooke, du Ministère de l'Environnement ainsi que d'une entreprise privée québécoise chargée de procéder à la conception, au développement et aux essais de ce nouveau type de boîte de camion. Nous prévoyons que cette boîte pourrait être disponible dans les prochains 12 mois.

USINE DE TRAITEMENT DES DECHETS VERSUS ENFOUISSEMENT SANITAIRE CONVENTIONNEL

On se souviendra que plus tôt nous avons souligné le fait que dès 1989, le sable ne serait plus disponible sur le site d'enfouissement sanitaire. Il fallait donc, à tout prix, trouver une méthode qui permettrait d'augmenter

la durée de vie du sable afin d'éviter d'avoir à faire des dépenses supplémentaires.

L'implantation d'une usine qui ne ferait que mettre en ballots la totalité des déchets reçus nous permettrait de diminuer de 0.8 à 0.2 tonne la quantité de sable requise pour l'enfouissement sanitaire d'une tonne de déchets. Ainsi, la durée de vie du sable se trouve augmentée par un facteur de 4. Donc, il est moins pressant d'acheter du sable de source extérieure.

Une fois cette phase muméro 1 acceptée par les autorités municipales, nous avons recommandé à ces dernières de procéder à une phase 2 qui consisterait à faire la collecte sélective des fibres, afin de pouvoir en permettre le recyclage, étant donné que l'usine de mise en ballots était déjà disponible en conséquence de la phase 1.

En résumé, dans la phase 1, nous faisons une mise en ballots en vrac des déchets reçus et en phase 2, nous procédons à la mise en ballots, toujours des déchets, mais de façon sélective. Nous mettons en ballots:

- le papier journal
- le papier kraft
- le papier fin
- le carton

afin de pouvoir vendre ces matières secondaires. Cette façon d'opérer diminuait à environ 40,000 tonnes la quantité de déchets qui restait à enfouir. Donc, la durée de vie du sable de disponible se trouvait encore augmentée de près de 20%.

Nos recherches nous ont permis de constater que la technologie de pointe nous permettrait de faire une revalorisation mécanique des déchets qui n'avaient pas été triés à la source. Nous avons donc proposé au Conseil Municipal, dans une phase numéro 3, de procéder à la production de combustible dérivée des déchets municipaux que l'on appellera CDDM. En effet, il devient possible de séparer mécaniquement la partie légère des ordures ménagères de la partie lourde et pétricible. Cette partie légère étant formée par les papiers contaminés, les plastiques et autres matières légères.

Il est possible à l'aide de densificateur de produire des briquettes qui pourront servir au chauffage de certaines industries ou de certaines institutions. Les quantités restant à mettre en ballots et à diriger vers le site d'enfouissement se trouvent ainsi diminuées d'un autre 30,000 tonnes annuellements.

Techniquement, il est aussi possible de récupérer la partie pétricible des déchets ménagers. En effet, à l'aide d'un digesteur, il est possible chimiquement de produire un compost pouvant servir à enrichir le sol de nos fermes québécoises. Il existe actuellement au-delà de 100 procédés différents de revalorisation des déchets municipaux, à savoir:

- compastage
- méthanisation
- pyrolise
- vapeur
- CDDM
- etc.

PROJET GLOBAL

GESTION DES DECHETS SOLIDES

SOMMAIRE

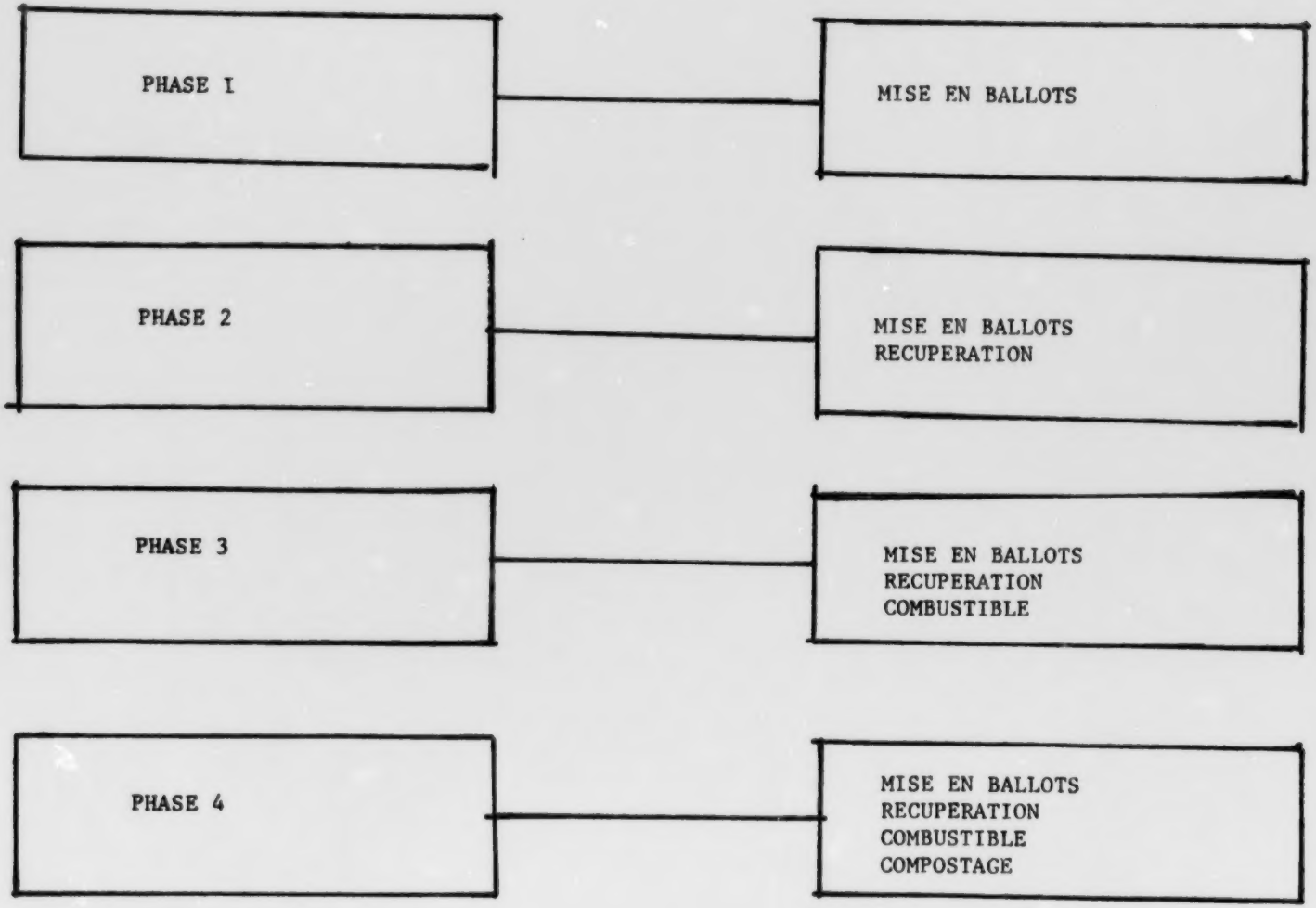
PHASE	INVEST. UNE FOIS $	OPERATION ANNUELLE $	REVENU ANNUEL $	PROFIT NET ANNUEL $
ACTUELLE	0	250,000	250,000	0
I	1,600,000	600,000	600,000	0
II	100,000	700,000	1,350,000 *	650,000
III	600,000	700,000 200,000 900,000	1,350,000 * 1,080,000 * 2,430,000 *	1,530,000
IV	700,000 3,000,000	700,000 200,000 0 900,000	1,350,000 * 1,080,000 * 380,000 * 2,810,000 *	1,910,000

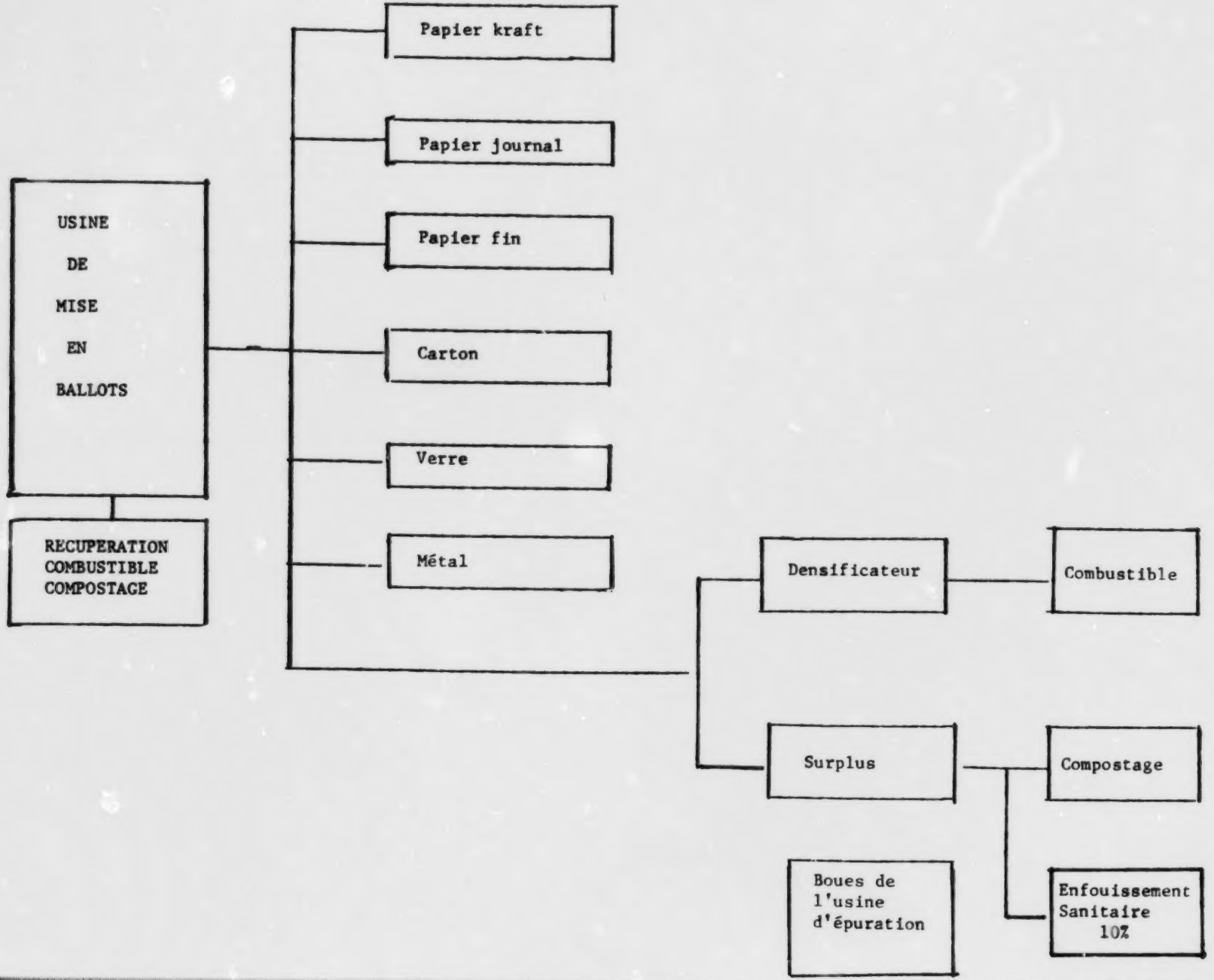
ECHEANCIER: 1er ANNEE PHASE I & II
3e ANNEE PHASE III
5e ANNEE PHASE IV

* TARIF NON INCLUS

NOTE: Chaque phase fera l'objet d'une étude détaillée avant sa réalisation

SOLUTIONS PROPOSEES




USINE
DE
MISE
EN
BALLOTS
RECUPERATION
COMBUSTIBLE
COMPOSTAGE
Papier kraft
Papier journal
Papier fin
Carton
Verre
Métal
Densificateur
Combustible
Surplus
Compostage
Boues de
l'usine
d'épuration
Enfouissement
Sanitaire
10%

En octobre 1985, nous avons recommandé au Conseil d'accorder à une firme d'ingénieurs privée, à savoir RECYTECH, le mandat de procéder à une étude de préfaisabilité devant servir à déterminer quel est pour la Ville de Sherbrooke le meilleur moyen de disposer des ordures ménagères arrivant actuellement au site d'enfouissement sanitaire.

En résumé, le plan global de gestion des déchets pour la Ville de Sherbrooke se compose de 4 phases distinctes, soient:

1. mise en ballots des déchets,
2. mise en ballots des déchets et récupération,
3. mise en ballots des déchets, récupération et production d'un combustible dérivé de déchets municipaux (CDDM),
4. production de compost

Il est important de souligner ici, qu'au niveau du compostage, nous pouvons inclure les 4,500 tonnes de boue provenant de l'usine d'épuration des eaux afin de disposer de ces dernières. Le résultat final de toutes ces opérations nous laisse avec environ 10,000 tonnes de matériaux secs au sens de la loi et donc, l'enfouissement sanitaire n'est plus requis pour l'ensemble des déchets.

Les coûts d'un tel projet se chiffrent à plusieurs millions de dollars et sont fonctions des procédés retenus.

Les revenus provenant de la vente des produits récupérés à la source et de la production de l'usine s'élèvent à quelques quatre (4) millions de dollars annuellement.

En admettant une possibilité d'erreurs de 50% sur les projections, les argents investis au niveau du Québec auront créé 20,000 emplois et réinjecté dans le système plusieurs millions de tonnes de produits qui autrement auraient été simplement enfouis.

En terminant, qu'il me soit permis de souligner qu'une meilleure gestion des ressources secondaires contribuera, à moyen terme, à protéger notre environnement en facilitant le recyclage des ressources secondaires.

Certes, la fermeture des sites d'enfouissement sanitaires n'est pas pour demain cependant, cela constitue un but à poursuivre et la technologie actuelle nous permet d'espérer l'atteinte de cet objectif dans un avenir relativement court.

DEVELOPMENT OF THE NEED FOR RECYCLING OR DISPOSAL OF HAZARDOUS WASTE IN AN ENVIRONMENTALLY SOUND FASHION

Kris Kudrnac

Anachemia Canada Inc.

Paper unavailable at time of printing

THE INDUSTRIAL WASTE PREVENTION PROGRAM IN THE REGION OF WATERLOO

Robert Booth
Environmental Protection Service - Ontario Region

INTRODUCTION

In 1982, the Ontario Regional office of the Environmental Protection Service, with the financial assistance of the Ontario Ministry of the Environment and the co-operation of the Region of Waterloo and the Kitchener Chamber of Commerce, udertook an industrial waste prevention program in the Region of Waterloo over a period of approximately 2.5 years, at a cost of $247,000. The program was based on an unsolicited proposal to the Department of Supply and Services from a consortium comprised of Resource Integration Systems (RIS), Ontario Research Foundation (ORF), Hans Mooij and Associates and Proctor & Redfern Ltd.

The ultimate objective was to develop and demonstrate a program that local governments could use as a model, either whole or in-part, to help reduce and manage industrial waste. The Region of Waterloo was selected becasue this program was a logical next step following their detailed inventory of industrial waste generation[1].

The program was in two phases - predemonstration and demonstration/eveluation.

PREDEMONSTRATION PHASE

Predemonstration activities included an industry survey, the preparation of industry specific technical manuals on waste abatement, reduction, reuse and recycling and a feasibility study on a transfer station for small volume generators. These activities indentified and provided the justification for the activities undertaken in the demonstration phase.

1. "An Inventory of Liquid and Special Waste for the Regional Municipality of Waterloo". Canviro Consultants Ltd. and Simcoe Engineering Ltd., April, 1982.

Industry Survey

The purpose of the industry survey was to determine attitudes towards waste management, the current status of waste management practices and barriers to improving these practices.

Forty eight industries of varying size were selected from three municipalities. In order to identify the influence of municipal bylaws on waste management practices the municipalities were selected based upon their strictness or laxity of enforcement.

The results of the survey were as follows:

- the strict enforcement of disposal bylaws has a positive effect on waste management practices however, some good actors were found in areas of low enforcement.
- large plants are more aware of good or bad practices and more willing to adopt new technoligies or procedures.
- the concept of waste reduction/recycling is well accepted.
- information sources for waste reduction options exist but are not readily available or regularly used.
- awareness of government assistance programs is low.
- community and environmental impact are important factors in decision making, however economic factors are of prime importance.
- industry wants to maintain a positive public image.
- The main barriers to change are a lack of understanding of the impact of current practicies and a lack of technical and financial assistance.

These results formed the basis for the demonstration activities.

Technical Manuals - Waste Abatement, Reduction Reuse and Recycling

One of the major tasks in the predomonstration phase was the development fo technical manuals on waste abatement reduction, reuse and recycling to fill the identified information needs. Manuals were developed for six industry sectors - organic and inorganic chemicals, primary textiles, food processing, primary metals and metal finishing. They were designed to provide information that could be readily used by plant waste management personnel to reduce the bolume and improve the quality of waste being produced. The information provided for each sector includes:

- sources, types and quantities of waste
- waste audit procedures
- waste reduction possibilities
- waste reduction technologies
- case studies
- sources of technical and financial assistance
- regulation overview

Before the manuals were released to industry in the Region of Waterloo the contents were reviewed by industries, trade associations and government engineering departments. The textiles and food processing manuals were field tested in industry by the consultants to ensure their utility.

Transfer Station for Small Waste Generators

The "Inventory of Liquid and Special Waste" indicated that a minimum of 227,000 litres per year was being improperly disposed of or stored. The bulk of this was from small waste generators and a transfer station was suggested in the inventory study as a potential solution.

A survey of small waste generators in the Region was undertaken to identify any barriers to the use of such a facility, the number of potential users, operator preference (government versus private) and any difficulties that might arise in labelling containers and separating waste streams for ease of recycling or disposal.

From the results of the survey it was evident that an educational program on the environmental hazard of small waste quantities was required before a transfer station should be considered further.

The main barriers to use were the convenience of the present disposal method (ie. disposal at the landfill, co-disposal, parking lot oiling) and the associated lack of awareness that this was not an acceptable practice.

Other conclusions from the survey were that technical information was required on packaging and waste stream segragation; the station should be operated by the Region until established and then turned over to the private sector and that regulatory and user cost considerations should be determined.

DEMONSTRATION ACTIVITIES

Both the industry and transfer station surveys indicated a need for the provision of information. The demonstration activities were therefore designed to actively meet this need and to provide as much assistance as possible to help an industry make a positive change in waste management practice. The activities included:

- an information centre with a waste hot-line
- a regional waste exchange
- a quarterly industrial waste management newsletter
- distribution of the technical manuals
- seminars and workshop
- special waste days for householders

Prior to the implementation of this phase of the program a letter of introduction endorsed by the Region Chairman was distributed to regional industry and a press conference was held to announce the program.

Information Centre

A waste exchange, based on the Canadian Waste Materials Exchange (CWME), was operated by the information centre for local industry. Transactions were usually made independent of centre staff, however some exchanges were arranged as a result of staff knowledge of local industry waste types, process and material needs. Listings were forwarded to the CWME upon request.

The exchange became widely known in the Region and achieved a success rate of approximately 23%. A more active approach could have increased the effectiveness.

Newsletter

A quarterly newsletter was distributed to 1150 companies. It included the waste exchange listings, information on changing regulations, articles on local companies' good waste management practices and a series on government incentives. Input for the newsletter was gathered from municipal and industry officials.

During the program evaluation it was found that 94% of local industry were aware of the newsletter, 71% found it beneficial and 82% wanted it continued. The newsletter was therefore, an effective means of transferring information to industry.

Technical Manuals

The technical manuals on waste abatement, reduction, reuse and recycling were distributed to industry through the information centre at the printing cost of $25.00 per manual. Several mechanisms were used to enhance distribution - advertising in the newsleter, circulation at the seminar and workshop and direct delivery by regional staff in the course of their day to day contact with industry.

Advertising in the newsletter was not effective even though the manuals were available on a trial period at no change. Direct distribution either at the seminar and workshop or to industries door step, was highly effective. The information was well received and initial comments positive, however a follow-up program for industry comments is presently being planned. These comments will be incorporated in the manuals to improve their utility.

Seminar/Workshop

Another method of providing informaion to small and medium sized industries was through seminars and a workshop. Three sessions were organized. The first two, one for the textile industry and one for general industry, were formally structured and not successful. The textile seminar had to be cancelled due to a lack of registrants and the general seminar failed to achieve the desired attendance, though preregistration was adequate.

The overwhelmingly successful approach was an informal peer group workshop, which was held for the metal finishing industry at the Kitchener Chamber of Commerce. Costs were minimal and information transfer maximal. Though technical experts were on hand most questions on waste management practices were answered within the peer group. All who attended found the session beneficial and would like to see it repeated on an annual basis.

Special Waste Days

Initiated by the Regional Council and subsidized by the Ontario Ministry of the Environment, two special waste days for householders were held in May of 1984 at the Waterloo and Cambridge landfill sites. A considerable effort was made to publicize the events through press conferences,flyers to community groups listing waste types, travelling displays and radio and TV coverage. Local newspaper coverage was found to be the most effective.

Over 200 household participated in the events bringing in a wide range of wastes including strychnine, cyanide, acids, paints, solvents and used oil Strict security precautions were taken and wastes were handled, bulked and transported to disposal by Mosaic Chemical Coorporation. The police, fire department and regional staff were in attendance.

An on site survey revealled that most participants would like the "days" to be repeated on a regular basis. It was concluded that in the future, convenience should be a central planning goal for such events.

Current Activities

The Region of Waterloo has adopted many of the demonstration activities into it's waste management program. The waste exchange has been expanded to include the Guelph area, a newsletter has recently been issued, an industry information session was held in late October and a facility to take household hazardous waste form landfill site an and operated every Saturday from Victoria Day to Labour Day.

SUMMARY & CONCLUSIONS

The Industrial Waste Prevention Program is a "carrot" versus a "stick" approach to effective waste management and brings about cooperative as opposed to adversarial relations between industry and local government.

Most of the initiatives indertaken will have a low financial cost to other municipalities since the development costs have been borne by the Waterloo project. Staff time is required for the information centre, the waste exchange, the industry newsletter and the organizing of peer workshops. Special waste days and the newsletter also require substantial financial committment.

Municipalities having regulatory authority for the operation of sewage treatment plants and landfill are directly affected by poor waste disposal practices and therefore, have the most to gain from an industrial prevention program. Their close contact with industry puts them in the most favourable position to implement a successful program.

The following conclussions can be drawn from this program:

1) Consistency of municipal bylaws and their enforcement would effectively improve industrial waste management practices.
2) A cooperative approach to waste management involving government, industry, and a broader public is effective.
3) Industry and trade associations generally put low priorities on waste management issues and therefore, some means of increasing industry awareness is required.
4) Government involvement in waste management is appropriate for the protection of social and environmental health.
5) Industrial waste reduction and prevention taken at a local government level can have a direct impact in the waste management activities of individual companies, thereby reducing or eliminating the need for expensive remedial action in the future.

MANPOWER AND COMMUNICATIONS: THE KEYS TO SOLVING ENVIRONMENTAL PROBLEMS

W.D. Armstrong
Energy Pathways Inc.

INTRODUCTION

Progress towards the solving of environmental problems continues to be slower than environmentalists would like to see. There are many reasons for this lack of progress, but the most critical relate to information and to time. Instituting and maintaining environmental control systems demands both, and these commodities are in short supply, especially in the small and medium sized companies that are responsible for many of our most persistent environmental problems.

THE DIRECTED EMPLOYMENT APPROACH

Environmental problems are not the only issues which are resisting solution. The state of Canada's economy, and particularly the persistence of high rates of unemployment, is a matter for universal concern. Over the past decade, our attempts to solve the problem of unemployment have become more complex — we have progressed from "make work" to "job creation" to "employment development" to the lastest phrase, "labour market management" — but the problem has remained.

For the past several years, Energy Pathways Inc. (EPI) has been applying a unique approach to addressing both environmental and employment issues. In pilot projects in Ontario and Nova Scotia, and in a full scale project in Ontario described in the accompanying brochure, EPI has been placing unemployed and underemployed engineers, chemists and technologists in companies with waste management problems and opportunities. The results have been impressive, both in terms of environmental improvement and creation of meaningful permanent employment: more than 80% of the employees obtained permanent jobs with their project employers or with other companies, and 35 companies — many of which had been hostile or indifferent to environmental control — achieved substantial improvement in waste management.

The seemingly simple approach of identifying a company that can benefit from improved waste management, finding an unemployed person with the skills to bring about this improvement, matching the company with the employee, and following up with technical and administrative support works because it addresses one of the main reasons why environmental problems are not being solved. What holds most smaller companies back from improving their environmental management is lack of manpower to identify and implement solutions. Staff time is fully occupied by production and sales, and the bewildering array of technical information available only makes it more difficult for time-short executives to consider waste management options. Providing companies with a skilled employee who can devote his or her full efforts to waste management breaks this deadlock and accustoms companies to treating environmental management as a routine part of doing business.

The targetted employment approach developed by EPI is based on broadly based consultations between government environmental and employment agencies, industry and educational institutions. Through these consultations, we have identified a number of unmet needs which are contributing to the slow rate of progress in industrial environmental control. The ultimate objective of our directed employment projects is to con-

vince industry that proper waste management can be a profitable part of doing business; in other words, to reach the point where companies will put out their own money to hire qualified environmental personnel rather than relying on government employment funding. If this objective is to be met, these unmet needs must be addressed.

The heart of the problem seems to be communications — getting the right kind of information into the hands of people who need it most.

TARGETTED COMMUNICATIONS

Much of the environmental information directed at industry treats "industry" as one entity, and tends to be highly technical. In practice, a variety of players are involved in an individual company's waste management decisions, and few of these players are technically fluent. At present, there is little factual motivational material aimed directly at those with executive, not technical, responsibilities — material dealing with paybacks, spinoff benefits and new product opportunities. And yet, if top management is not committed to improving waste management, a company won't move.

Even at the technical level, there are communications shortfalls. Technical materials tend to be too general for plant technical and quality control personnel, who need specific examples of approaches they can apply on their own shop floors. There is a real need for sector-specific case studies of real-life situations, and for comparative, objective evaluations of available equipment and services.

As matters stand, technical people in many small and medium companies are at the mercy of whatever suppliers happen to pass their way, and lack objective information that can help them decide what is best for their particular needs. As a result, even companies with qualified environmental staff may be paralysed by indecision. Government environmental agencies have the resources to provide the sort of objective information needed, but there is a tendency in government to avoid giving product-specific advice. In view of the lack of other sources of balanced information, this attitude should be reconsidered.

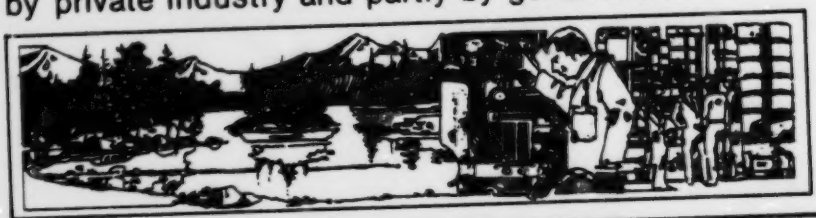
At the heart of the matter is a lack of meaningful consultation and communication between and within the private and public sectors. Federal and provincial agencies dealing with environment, industrial development, employment and education need to put more effort into meeting their individual agendas through coordinated joint ventures, maximizing the return on their efforts and avoiding duplication. When EPI has brought these agencies together in consultations related to our projects, it has been the first time that many of these players have met and communicated. They have, in general, been pleasantly surprised to find how their individual needs overlap and complement each other.

Overall, we have reached the conclusion that while there are copious quantities of environmental information available, little gets through to the intended audiences in an effective way. In our role of project manager/information broker, we compensate by committing considerable time and energy on a case-by-case basis. In relatively small, controlled pilot situations this is an adequate, though expensive, approach. However, if the thousands of firms who could dramatically improve their waste management are to be motivated and served, greater emphasis must be placed on identifying the key people in the decision-making process, understanding their needs, fears and perspectives, and delivering high quality information where it is needed most.

Stimulating Industry, Technology and Employment in Ontario

What is ON-SITE?

ON-SITE is an innovative approach to creating new permanent jobs and improving Ontario's industrial productivity through cost-effective environmental protection. It is a cooperative effort sponsored partly by private industry and partly by government.



What does ON-SITE do?

ON-SITE addresses three pressing problems in Ontario's industrial sector:

- Environmental control and regulation are becoming increasingly complex. For many small and medium-sized companies, responding to regulatory demands is expensive and difficult.
- The economic climate is increasingly competitive and the cost of new pollution control systems is high. Companies lacking in-house environmental specialists are often unaware of new technologies and methods and of available financial assistance for capital expenditures.
- A tight job market has resulted in thousands of young professionals in engineering and environmental fields being either unemployed or underemployed. These young people have the skills that industry needs and represent an enormous public investment in terms of their education and training.

ON-SITE attacks all three problems at once, by placing young professionals in small and medium industries faced with environmental control requirements. Federal government funding is used to help pay these employees' salaries, but the project is operated by independent private sector firms and participating companies have no direct contact with government agencies.

How does ON-SITE work?

ON-SITE has been designed to place young professionals in industries which require their skills with an absolute minimum of paperwork or delay. Energy Pathways Inc. (EPI), a private sector service company, provides overall management of the project. Tricil Limited, a leading Ontario waste management firm, provides financial support and technical expertise.

In operation, ON-SITE brings together many players with a direct interest in employment, environmental protection, waste management and industrial productivity:

- Labour supply advisors from government agencies concerned with employment, professional associations and colleges and universities help identify project workers with the appropriate skills.
- Labour market advisors from industry associations and government agencies concerned with industrial development help identify industrial sectors and specific companies which might benefit by taking on a project worker.
- Technical support and training is provided to project workers by experts drawn from Tricil, colleges and universities and private consultants in a number of disciplines.

The way ON-SITE works is simple and direct. Firms recommended for involvement by industry representatives are contacted and briefed on the project. If they wish to participate, a job description is developed to meet both the needs of the individual company and ON-SITE. Next, a list of prescreened candidate employees is provided to the company, which conducts final job interviews and employee selection. Once placed, the employee operates under the direction of the participating company; however, all or a portion of salary and benefit costs are paid directly by ON-SITE.

The work term of the employee under ON-SITE is approximately six months; following this period, the participating company is free to directly hire the individual. There is no obligation to continue employment at any time during or after the project. During the project, the employees are given additional training in areas related to their responsibilities. Again, the costs involved in these training sessions are paid by ON-SITE.

Does ON-SITE work?

Pilot projects in Ontario and Nova Scotia have shown that cooperative employment development works. The Ontario pilot yielded extremely good results for the 17 participating firms. Each achieved real improvements in waste reduction, reuse and recycling and increased management awareness of the penalty for poor waste management. The firms were impressed enough by the process that they spent, on average, $25,000 in expenses and investments in new technology and were unanimous in their praise of the project. Sixty per cent of the project employees were retained by the participating companies in new permanent positions, and 25 per cent found permanent jobs with other companies.

In short, ON-SITE benefits everyone involved:

- *Employees* gain valuable work experience and realistic prospects for permanent employment in their field.
- *Companies* cut costs and improve waste management.
- *Government* achieves effective return on funds provided, in terms of job creation, stimulation of private sector investments in new technology and pollution reduction, all without regulatory intervention or excessive cost.

ON-SITE was developed with one goal in mind — to find a constructive way for government and industry to work together in dealing with environmental protection. The young people graduating from Ontario colleges and universities are, in many ways, the key. They have the skills and the enthusiasm to get the job done. What they need most is a chance to prove themselves.

Finding The People To Do The Job

Finding the right waste management professional for a particular company's operation can be a lengthy and frustrating process, especially for a small company. ON-SITE takes the work and worry out of this search; instead of having to sift through a bewildering array of job candidates, participating companies select their employees from "short lists" of carefully prescreened candidates. EPI deals with the paperwork needed to obtain government funding assistance for employee salaries and handles the time-consuming initial search for employees.

The Employees: Who Are They?

A typical ON-SITE employee fits the following profile. He/she is young and has professional training ranging from a diploma in chemical engineering technology to a university degree in chemistry, biology or engineering. Having successfully learned the techniques and theory of environmental control and abatement, this individual has graduated into a tight job market and few prospects of a career in his/her field.

These young professionals are caught in the job experience "Catch- 22": no experience, no job — no job, no experience. ON-SITE provides them with the chance to prove themselves. And prove themselves they do — past experience has shown that more than 80 per cent of these employees will find permanent employment at the end of the project.

How Many Are Available For Work?

Are there really that many qualified people available for work? Indeed there are — both professionals and technicians. Recent surveys of Ontario graduates in chemistry, chemical engineering technology and chemical engineering paint a bleak picture:

- only 60% of 1982 chemistry graduates were employed one year after graduation, and only half of these in the field of physical sciences;
- similarly, only 65% of 1984 graduates of chemical engineering technology had found work, although most who did were working in their field of training; and
- a recent survey of spring 1985 graduates in chemical engineering revealed that fewer than 20% had found permanent jobs in engineering.

Literally thousands of the highly trained young people graduating from Ontario colleges and universities every year will not find jobs in their fields of training. Across the country, it is estimated that more than 60,000 professionals are temporarily or chronically unemployed. Indeed, our most serious waste problem is the waste of these young people's talents and energy.

Small companies may wonder why, if there are so many qualified people seeking work, they are not hearing from them. The answer is simple: like the companies themselves, job seekers do not realize the opportunities that exist to apply their talents to waste management. ON-SITE solves this dilemma by bringing potential employers and employees together.

Employee Training: Focussing on Real World Concerns

What makes ON-SITE work is its emphasis on the real world — the challenges that are faced on the shop floor every day. Companies can be sure they are getting employees with the most up-to-date training and information because:

- interview candidates are prescreened to ensure that their qualifications and abilities meet company needs; and
- all ON-SITE employees attend comprehensive training sessions where they receive the most up-to-date information and advice from waste management industry leaders.

The week-long training sessions are coordinated by Tricil, and feature presentations and discussion sessions with representatives from government, research organizations and testing labs, universities, waste management consultants and companies which have developed innovative solutions to their own waste management needs. Seminars cover a variety of topics, including: recycling, reuse and recovery of wastes; regulations; analysis and monitoring; and waste treatment methods.

Shorter, follow-up seminars provide supplementary information. In addition, employees are provided with a variety of technical manuals and literature, and have access to an on-call technical advisory service provided by ON-SITE.

Keeping up-to-date is essential in today's changing waste management environment. ON-SITE's emphasis on "real world" training and technical advice ensures that participating companies, through their project employees, are able to take full advantage of their waste management opportunities.

Questions and answers for participating companies

Who can participate?

Any company in southern Ontario needing waste management assistance can apply. One hundred companies will ultimately be selected, based on a variety of criteria including geographical location, business sector and government funding requirements.

What do I do if I want an employee?

Simply call or write EPI. We will immediately determine whether we can help you.

If I qualify, then what?

EPI will help you develop a clear and concise "job description" outlining the type of work your employee will be expected to do and the technical qualifications required. With assistance from colleges, universities, professional associations and government employment agencies, EPI will investigate suitable candidates for the job. We'll screen the candidates' qualifications and give you the names and resumés of several promising prospects. You then conduct the interviews and take over from there.

What do I do once I've hired my employee?

Your employee is just that — your employee. You determine his or her duties and provide day-to-day supervision just as you would for any other employee. EPI handles the administrative end — we distribute the government-provided salary and benefits funding and do the bookkeeping, reporting and other paperwork required for government funding. Tricil coordinates periodic training workshops and provides up-to-date technical information and technical back-up services. All you have to do is ensure that biweekly time and activity reports are filled out and forwarded to EPI.

Who can I hire?

You can hire anyone who meets the requirements of the federal employment funding program. In the past, we have placed men and women with a complete range of technical and professional skills. In some cases, companies have brought their own candidates forward, either from applications on file or based on past experience with the company.

Can I keep this employee when the funding ends?

Definitely yes. In past projects, most of the participating companies have kept their project workers on as permanent employees at the end of the work term. These companies have found that waste management can be a profitable part of doing business.

Will my records be kept confidential?

Yes. Just as you manage the day-to-day work of your project employee, you also decide what information is confidential or proprietary. Activity reports are cleared by the employee's supervisor and their contents are held in strict confidence by EPI.

Am I covered against liability?

During the project, the project worker is the legal employee of EPI. Employment programs are covered by third party liability insurance and employers have Worker's Compensation coverage. All we ask is that project workers be treated in the same manner as permanent employees.

How much paperwork do I have to do?

Very little — we do it for you. All you have to do is ensure that your employee fills out brief biweekly progress reports.

Profiting From Waste Management: Three Case Studies

Taking advantage of waste management opportunities can mean different things to different companies. To a small firm, the whole concept of managing wastes, as opposed to merely disposing of them, may be new. Often, the cost of wastes in terms of lost productivity and disposal costs is unknown, or seen as an inescapable cost of doing business. Sometimes immediate priorities of production and sales prevent the development of a long-term plan to eliminate wastes.

For these firms, the first step is to define waste management opportunities and design a workable strategy. For larger firms, obtaining an extra employee who is professionally qualified can allow the expansion or acceleration of existing waste management, environmental control or quality control activities. Opportunities for improved productivity and environmental control are usually present even when waste management activities are an established routine.

What sort of work will my employee do?

Whatever you specify in your job description. But we won't confine you to that absolutely. We recognize that waste management is an ongoing function and not easily restricted to firm goals. What we expect is that you will stick to the overall objectives of the project and the job description — in other words, that you'll provide your employee with a reasonable chance for professional development.

What if the employee doesn't work out?

If you feel you have just cause, you may dismiss your project employee, just as you would any of your other employees. If necessary, EPI will help you find a replacement.

Can I change my mind?

Of course. We recognize that priorities can change at any time during the project. If this happens, you are under no obligation to continue.

The challenge of changing environmental regulations

Regulations governing industrial waste management in Ontario are now more detailed and stringent than ever before. Legislation passed in June 1985 provides that, as of September 1985, companies generating liquid industrial or hazardous waste have much greater responsibilities in regard to the management and disposal of these wastes. Included in the new regulations are:

- ***Generator Registration***: Any company creating or storing liquid industrial or hazardous wastes, as defined in the regulations, must register with the Waste Management Branch of the Ministry of the Environment to obtain a generator registration number and a waste number for each type of waste produced. To obtain these numbers, the company must analyze and describe the physical and chemical characteristics of its wastes.
- ***Manifests***: An expanded system of "manifests" has taken the place of the previous system of waybills governing the hauling and disposal of industrial wastes. A sixth copy of the manifest has been added — this copy must be sent by the waste receiver to the waste generator once the waste has been safely delivered to its final disposal site.
- ***Transportation***: Generators of hazardous wastes must package or mark these wastes so that they meet the requirements of the federal Transportation of Dangerous Goods Act before transferring them to a waste transportation system.

What Do These Regulations Mean?

To comply with the new regulations, companies are going to have to have tight internal control over their wastes; in other words, they are going to need defined and rationalized waste management systems. To be

Every sector of industry must deal with solid, liquid or airborne waste. Experience in earlier projects has shown that some of the greatest waste management challenges are faced by manufacturers, by food producers and by specialty operations such as electroplaters. As the following case studies from an earlier EPI employment project show, the ON-SITE approach can be successfully applied to meet a wide range of industrial challenges.

CASE 1: Electroplating

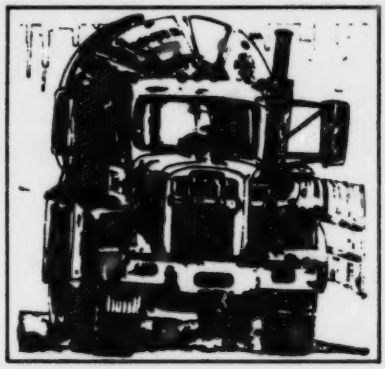
A small electroplating firm in southern Ontario which employed a wide range of electroplating techniques was losing large quantities of heavy metals and toxic chemicals into its waste stream because of lack of monitoring and quality control. Plant waste waters could not be disposed of through the municipal sewer system because of this contamination, and the cost of having waste water hauled away was substantial

The challenge of changing environmental regulations (cont'd)

able to identify exactly what wastes they produce and in what quantities, most companies will need in-house expertise and facilities for waste analysis. Keeping up with the paperwork of the manifest system and with changes and exemptions will also require additional staff time.

Even the smallest companies will require qualified personnel to:

- establish and maintain a waste management system, including provisions for dealing with emergencies;
- identify what types of wastes are produced, from what operations and in what quantities;
- analyze and describe the wastes being generated;
- keep up with the paperwork associated with the manifest system; and
- ensure that wastes are packaged or marked in



accordance with the Transportation of Dangerous Goods Act.

At present, many small and medium-sized companies lack this type of in-house expertise. Without qualified personnel and rational waste management systems, these companies will be under increasing pressure from regulatory agencies. ON-SITE is designed to help these companies by providing them with carefully selected and highly trained young professionals who understand Ontario's changing regulatory environment.

The Bottom Line: Improving Profitability

Complying with regulations is important, but there's an even better reason for companies to improve waste management — $$! Many companies are literally pouring money down the drain, paying heavy sewer surcharges or haulers' fees to dispose of wastes which, in most cases, could be greatly reduced in volume, recycled or avoided completely. Most companies who participated in the earlier pilot projects retained their project workers at the end of the project because the savings these workers generated paid for their salaries many times over — some companies are now saving tens of thousands of dollars annually in reduced surcharges and hauling fees.

Money saved by good waste management is money that can be invested in production. In today's tight economy, it's the companies with the most efficient operations who will prosper.

Profiting From Waste Management: Three Case Studies (Cont'd)

and rising. Without trained personnel to analyze its process and waste streams, this company could not reduce waste quantities and disposal costs.

The project worker filled this gap. A Resource Engineering Technologist, she had been working part-time as a roller rink attendant, unable to find a job in her chosen field. The company put her name forward as a possible employee and, as she met the project criteria, she was accepted and hired.

After familiarizing herself with company processes and routines, the project worker visited regional municipality laboratories and the labs of an electroplating chemical supplier. There, she learned the most up-to-date techniques for analyzing waste waters and determining concentrations of trace metals, cyanides and cyanates. She then applied these techniques to her employer's operations.

During her work term, the project worker suggested and initiated a number of improvements. A regime for daily monitoring of waste waters was put in place, along with a chemicals inventory system. Routine analysis was initiated to improve quality performance and monitor any misuse or unnecessary treatment/disposal of plating baths. An in-plant treatment system was installed to treat, settle and filter waste waters to remove metals and sludge. The resultant liquid stream can now be disposed of through the municipal sewer system; savings in hauling

Profiting From Waste Management: Three Case Studies (Cont'd)

fees are substantial. The addition of a "drag-out" tank on the nickel chrome line directly behind the nickel tank reduced the amount of nickel entering the rinse tanks; the drag-out tank is also used to top up the plating bath, returning valuable nickel to the bath.

In addition to improving waste management, the project worker identified opportunities for energy conservation. Coolant water for the chrome and bright acid copper tanks, which had been flowing continuously in flexible pipes through the solutions and then out into the sewer system, was redirected into the rinse tank, resulting in a substantial saving of fresh water. Spent chiller water from the anodizing line is now used to heat the zinc and chromate tanks, eliminating the need for heating units.

By the end of the project work term, the project worker was fully integrated into company operations. She is now a permanent employee, responsible for routine analysis of plating tank contents and of waste treatment, and for providing constant input to plant operations personnel to ensure that tanks are kept at optimum operating conditions. Through her efforts, this electroplating company continues to improve the efficiency and profitability of its operations.

CASE 2: Food Processing

A major manufacturer of food additives had problems with high BOD effluent at one of its plants in southern Ontario and was paying heavy surcharges to dispose of the effluent through the municipal sewage system. The company was aware of the problem, but lacked the staff to deal with it. After being briefed by an EPI representative about the pilot job creation project, company management readily agreed to participate.

The project worker selected by the company was a recent graduate in Resources Engineering Technology (Air and Water). Without experience, he had not been able to find a job in his chosen field, and was working as a waiter when he learned of the project from an EPI representative. After a company interview, he was hired.

The project worker's main task was to analyze all liquid streams in the plant to determine the reasons for the high effluent BOD levels. He carried out extensive effluent sampling and testing of BOD, total solids and settling ability of suspended solids and checked for leakage in plant collection drains.

As a result of his tests, the company was able to set in place an inexpensive system to recycle some of the streams and reduce effluent loads. These steps, combined with other measures which had been initiated prior to the hiring of the project worker, reduced the surcharges by 50%; more than half of this reduction was attributable to the project worker's efforts.

Company management were impressed by the project worker's accomplishments and by the way he fit into a fairly large (250 employees) operation, and offered him a permanent position at the end of his work term. However, with valuable practical experience under his belt, he had no problem finding other interested employers and, for personal reasons, chose to accept another offer from a manufacturer in his home town.

CASE 3: Manufacturing

A southern Ontario manufacturer of custom carpet overlay for the automotive industry continues to employ its project worker in an ongoing program to profit from waste management opportunities. The resins used in the company's manufacturing process are phenol-based, and management was very interested in participating in the pilot because the company had a severe problem with both airborne and waterborne phenolic wastes. In fact, municipal authorities had given the company a 3-year deadline to clean up its phenol-contaminated waste waters.

The project worker chosen by this company was a recent graduate with a B.Sc. in chemistry who was having trouble finding a job because of his lack of commercial laboratory experience. He was unemployed, collecting Unemployment Insurance benefits, and was very eager to participate in the project. His enthusiasm, technical abilities and communications skills soon had an impact on his new employer's waste problems.

Company management were well aware of the importance of improving waste management, and had formed an "Effluent Quality Committee" made up of plant research and engineering staff, as well as management. The project worker was made a member of this committee, which in a meeting early in the project established priorities for his work. Most of his duties revolved around analyzing for control parameters in an attempt to reduce the quantities of contaminated effluent at source.

The project worker presented various proposals to the committee and the company president, and spent a fair amount of time preparing reports for provincial and municipal authorities on progress towards waste management goals. By the end of the project, he was working on new product development activities, as well as waste management. At the end of the project, he was offered and accepted a permanent position as an R&D technologist; he will continue to be involved in effluent quality control for several years, until the waste management systems are fully operational, but will become increasingly involved with new product development. According to the project worker, "I would not have even been considered for this position without my participation in this project". Having proven his worth to the company many times over, he continues to make a positive contribution to improving productivity.

Where do I fit in?

The key to the success of ON-SITE is support and involvement from a wide variety of players in private industry, government, education and research. At this point, we are developing the administrative framework for the project, determining the makeup of the labour supply, labour demand and technical support groups and establishing the groundwork needed to access employment funding. To do this, we need advice and ideas from those players who are closest to the action.

We hope you'll want to be a part of this exciting development in Ontario's waste management scene. If you want more information or wish to comment on the project, please call or write:

Bill Armstrong or Ann Simpson
Energy Pathways Inc.
251 Laurier Avenue West
Suite 304
Ottawa, Ontario
K1P 5J6

(613) 235-7976 or 235-5303

Who are we?

Energy Pathways Inc.

We are an independent Ottawa-based consulting company specializing in project design and management in employment, energy and the environment. Our approach is to bring together technical, communications and management specialists to deliver fully integrated projects.

Tricil Limited

We are a leading Canadian waste management company based in Mississauga. Jointly owned by Trimac Limited and C-I-L Inc., we combine the know-how of Canada's largest highway hauler of solid and liquid bulk materials with a century of experience in the research, manufacture and application of chemical products. Tricil is the only Canadian company to provide waste management services in three separate business areas — liquid and solid chemical wastes; solid waste; and the use of wastes to generate energy.

Why are we involved in this project?

Energy Pathways Inc.

For nearly a decade, EPI has provided marketing, communications, management and evaluation support to a wide range of public sector programs. During this time, we have had the opportunity to observe the conditions which best ensure a project's efficiency and success. For the past several years, we have been applying these lessons to the problems facing Canadian industries in the profitable management of waste and maximization of productivity.

These problems can be solved — the necessary skills and tools are there, but are not being used because of roadblocks ranging from poor communication to organizational intransigence. EPI's approach is to act as an "honest broker", bringing together industry, government and educators in projects which improve productivity, create jobs and reduce pollution. Without EPI playing the "third party" role of motivator, organizer and negotiator, projects like ON-SITE just don't happen. With EPI acting as a catalyst and providing independent management support, a variety of players can use projects such as ON-SITE to further their own specific goals while addressing common problems.

Tricil Limited

We at Tricil firmly believe that Ontario's industrial waste problems can be solved by the private sector with government support, not active intervention. What is needed is for industries to be given a chance to learn and apply effective waste management techniques.

ON-SITE gives industry this opportunity. As one of North America's leading waste management companies, Tricil has the up-to-date technical expertise that is needed to tackle industrial waste problems. We support ON-SITE because we believe that it is up to the private sector to demonstrate that proper waste management can be just another part of responsible business practice.

3 HAZARDOUS WASTE INCINERATION CASE HISTORIES:

- Chlorinated liquids
- Low level Radioactive Solid Wastes
- Biomedical Solid Wastes

Presented to:

7th NATIONAL CONFERENCE ON WASTE MANAGEMENT IN CANADA

OTTAWA, NOVEMBER, 1985

By

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TRECAN LIMITED
MISSISSAUGA, ONT.

INTRODUCTION:

"Hazardous Wastes" is a fairly recent buzz-word. Ten years ago, or more, some of the same wastes now reffered to as hazardous were being incinerated very successfully and were attracting little attention because the equipment worked. It worked because it was designed carefully to do the job required. It was only when a system was asked to incinerate a waste that it was not intended to incinerate that the bad publicity resulted.

This paper will briefly describe three completely different and separate waste incinerators which incinerate hazardous wastes, and none has attracted any publicity -- good or bad -- simply because they work.

One is for liquids and the other two are for solids. We could have included incinerators for gaseous hazardous wastes as well, but for time constraints. Our point to be made is that you have not heard much about any of these because trouble-free operation does not make for interesting news.

We believe, however, that the operating experiences of the facilities we will describe are pertinent to this conference. They point out the fact that wastes which are considered hazardous -- and rightly so -- can be destroyed in carefully designed incinerators.

In each of the three cases the following will be addressed:

A. The Waste Make-up and Through-put.

B. The Equipment Design.

C. The Operating Results.

CASE 1 -- Chlorinated Liquids

LOCATION: University of British Columbia
Vancouver, B.C.

WASTE MAKE-UP: Chlorinated liquids such as trichloroethylene, carbon tet, chloroform and methyl trithion;
Non-chlorinated liquids such as acetone, toluene, methyl and ethyl alcohol, benzene and motor oils.

WASTE FLOW: 270 lbs./hr. (123 kg./hr.) Design
3 MM Btu/hr. Heat Release.

EQUIPMENT DESIGN:

Fig. 1 shows a schematic cross-section of the incinerator. This is a down-fired system starting out with a high intensity combustor into which the waste is atomized, and in which auxiliary natural gas is also burned if required to sustain combustion. The result is a combustion gas stream in which the waste has been converted into CO_2, H_2O, and HCl. It is at a temperature of about 2500F (1400C). Direct contact cooling is done first by the gases bubbling through water in a submerged exhaust manner, and then with further water sprays. To neutralize the HCl formed when burning chlorinated liquids, dilute caustic soda is also sprayed into the cooling chamber. The cooled gases at 120F (50C) are then pulled through a venturi scrubber in the event any particulates are present, and finally through an I.D. fan and into the stack.

The photos following show this incinerator in place at the U.B.C. facility.

OPERATING RESULTS:

This incinerator has been operating since 1973 and quite satisfactorily. It is operated irregularly for 4 to 6 hours per day and as many days per week as the waste generation rate calls for. The University is currently investigating the purchase of another unit of the same design, but for twice the waste capacity, so the wastes being burned are increasing.

After about 10 years of service, in 1983, the Hastelloy B downcomer tube into which the burner fires was replaced, since gradual corrosion had required this. This has been the only maintenance cost of any consequence.

CASE 2 -- Low Level Radioactive Solid Waste

LOCATION: Chalk River Nuclear Laboratories,
Atomic Energy of Canada, Chalk River, Ontario

WASTE MAKE-UP: Dry combustible wastes, including paper, cardboard, clothing, caps, gloves, containers, and similar materials coming from an area of the facility classified as radioactive. Radiation level is less than 100 mR/hr. @ 30 cm.

WASTE THROUGH-PUT: 300 cu. ft. per day (8½ Cu. metres)
1 - 1½% max. PVC materials
average density: 8 lbs./ft.^{3}

EQUIPMENT DESIGN:

Fig. 2 is a schematic of the Chalk River Incineration System. The important components are the stainless steel primary chamber, the after burner chamber, the gas to air heat exchanger, the fabric filter and the HEPA filter. The primary chamber of this controlled air type incinerator is stainless steel lined rather than the normal refractory lining to allow it to be cleaned periodically. If it were refractory, the radioactivity in the ash would build up in the refractory and it would eventually need to be removed and disposed of.

The temperature in the primary chamber of 650° C (1200° F) allows this stainless steel construction.

The after burner as a conventional excess air chamber with an exit temperature of 1000° C (1800° F). The volatiles driven off in the primary chamber are consumed and converted to CO_2 and water vapour. Since the radioactivity in the waste stays in the ash -- in the primary chamber -- a refractory lined construction is used in the after burner. A scrubber for HCl removal is not needed because the quantity in the waste charged is kept low enough to insure an acceptably low condition in the stack.

OPERATING RESULTS:

The use of a fabric filter plus a HEPA filter in this Chalk River facility is a "belt and suspenders" approach. In the first two years of operation, the HEPA filter elements were never replaced. The particulate carryover caught in the fabric filter is less than 0.1%, which is well below the Ontario MOE regulations for particulates even if it were released to atmosphere, which it isn't.

The ash from the primary chamber combustion settles onto a removeable grate at the bottom of the conical chamber and is allowed to fall into a container which, when filled, is removed for ultimate disposal by burial. The overall volume reduction is about 25 to 1, and that is the real purpose of this incinerator.

It is now in its 6th year of operation.

Following are some photos of the facility, including the building, housing, the incinerator along with other parts of the Chalk River Waste Processing System. Note it is built on the side of a hill, which allows the waste to come into the building at the upper level and be discharged 3 floors below. The incinerator is vertical to make use of a "free" force -- gravity.

Aside from some seal and expansion joint replacements, which were not particularly serious and were anticipated after a few months of operation, there have not been any operating problems worth reporting. It is important to note however, that before designing and building this incinerator, we had the very important "point on the curve" of a Mark I version at Ontario Hydro at the Bruce Generating Station. This incinerator had real problems with over heating of the tube sheet on the gas to air heat exchanger downstream on the tube to tube sheet connections. Another problem was warping of the stainless steel liner to the primary chamber. The warpage took the distinct shape of the spiral cooling baffle behind the liner. Both of these problems were addressed and corrected in the midst of the design for the AECL incinerator, since the Ontario Hydro unit had been operational for abouth 6 months at that time.

CASE 3 -- BIO-MEDICAL SOLID WASTES

We mentioned a moment ago that we had the important advantage in the AECL incinerator at Chalk River of having had a "Mark I" to refer to. This is not always the case, unfortunately.

First, the statistical details:

LOCATION: Decom Medical Waste Systems Inc.
Gatineau, Quebec,

WASTE MAKE-UP: Bio-medical wastes from hospitals, clinics and pharmaceutical houses and medical laboratories
(There are two incinerators at this plant)

WASTE THROUGH-PUT: Incinerator No. 1 - 500 cu. ft. (14 cu. m.) per charge with one charge per 24 hrs. This amounts to about 3000 to 4000 lbs. per charge (1350 to 1800 kg.)

Incinerator No. 2 - Designed for 1200 lbs./hr. (540 kg./hr.) on a semi-continuous basis.

EQUIPMENT DESIGN:

Incinerator No. 1 - The Batch Charged Unit

Fig. 3 shows the batch charged incinerator configuration. It consists of refractory lined primary and secondary chambers with auxiliary gas burners in each. The primary chamber is where the waste charged is ignited and volatilized into CO, H_2 and smoke in a starved air mode. This gas stream is burned to CO_2 and H_2O in the secondary chamber in an excess air mode. The ash remains in the primary chamber.

The cycle takes 20 to 24 hours to complete. At this point the ash is manually removed so that the next charge can be loaded. Currently, an additional quantity of waste (about 25%) is charged about 3 to 5 hours into the cycle.

OPERATING RESULTS:

The only reportable problem has been liquids from within the waste charge getting into the air inlet pipes in the primary chamber. Also, the operators lay some loose materials on the floor before charging to minimize ash adhering to the floor.

This incinerator is shown in the following photos, including a before and after condition of a charge of waste and the following morning's result.

Incinerator No. 2 - The Continuous Feed Unit

Incinerator No. 2 -- the semi-continuous feed and discharge incinerator -- is shown in Fig. 4. The primary chamber is made up of a primary hearth onto which the waste charge is pushed by a ram, followed by a transfer ram and an ash discharge ram. Two ignition burners are in the primary chamber. The secondary or afterburner chamber is conventional with an auxiliary burner and excess air ports.

There are roof mounted water sprays which are used to keep the temperature in the primary chamber from over-shooting and in turn causing glass to melt and adhere to the hearth.

Although the amount of air needed in the primary chamber is small, in keeping with the starved air concept, some combustion air is of course needed. Also, it needs to be controlled based on what is happening in the chamber from a combustion standpoint. If the waste make-up were consistent, and known, this would be an easy task. It is not any easy task in this case. The wide variations in heat content of the waste -- which range from 4000 BTU/lb. to 14,000 BTU/lb. -- and wide variations in the liquids content ranging from water and hydrogen peroxide up to solvents such as Varsol, make the combustion conditions truly unpredictable. Thus, the judgement of the operating personnel as to how often a charge is put into the incinerator is a vital part of the process. This is between 10 and 20 minutes. The size of each charge is limited by the cavity ahead of the charging ram. This is 50 cu. ft. which represents an average weight per charge of 200 lbs. All materials to be incinerated are contained in plastic bags and in turn are contained in cardboard boxes or fiberboard drums. This procedure represents a secure method of transporting

and handling the waste, but precludes any inspection prior to charging. The operator finds out what was in a charge -- if he wants to know -- by looking into the signt ports in the primary chamber at the boxes after the cardboard and plastic bag have charred away enough to expose what is inside -- maybe. Temperature excursions up and down are also frequent. The photos following show this incinerator.

OPERATING RESULTS:

In the first 5 months of operation, this incinerator has been down for components being reparied or the system being modified about as much at it has been in regular operation. But significant progress has been made, and we as the manufacturer must acknowledge the patience of Decom during this period. It is operating on a regular and consisten basis.

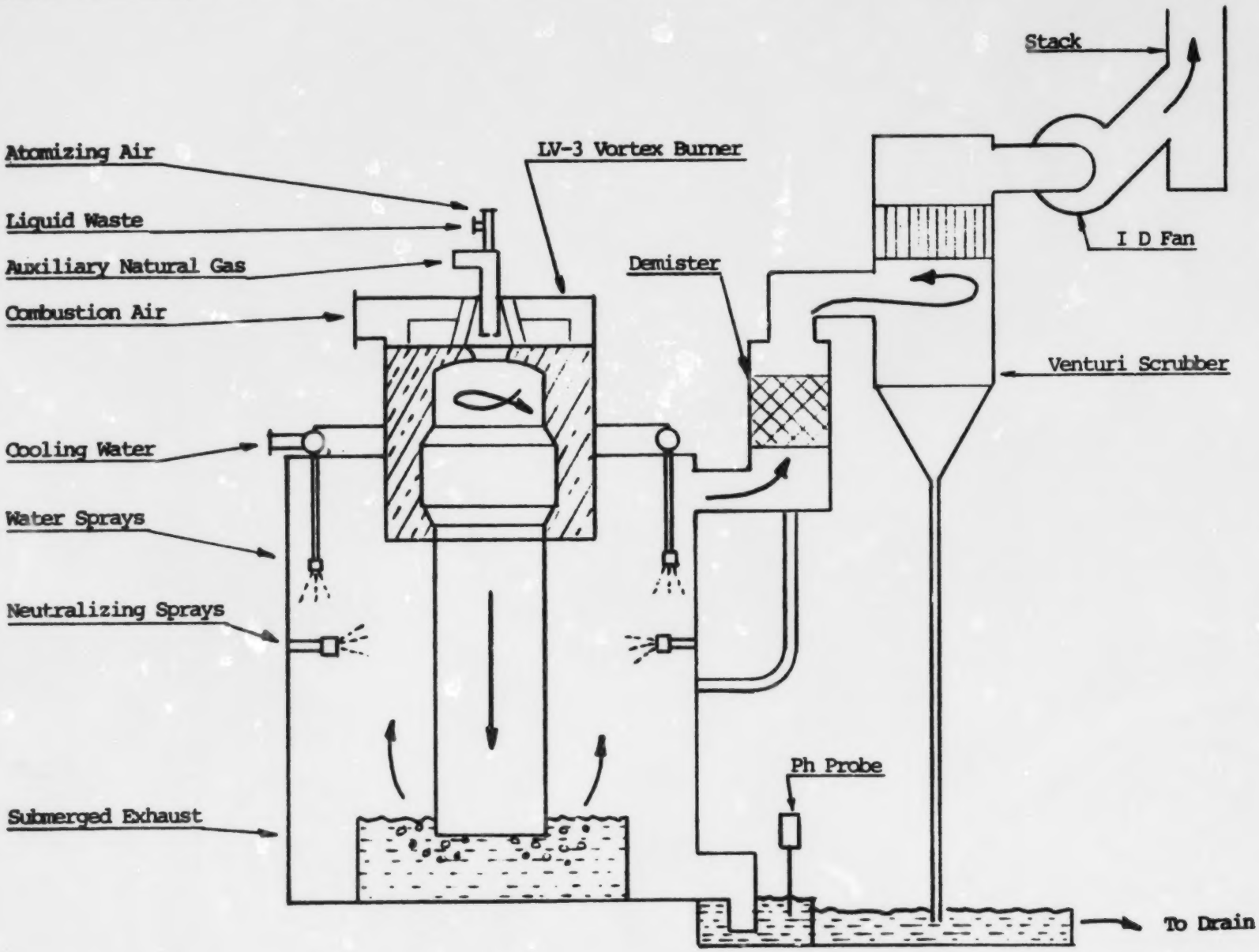
The most significant problem has been the through-put being 20% to 40% lower than the 1200 lbs./hr. design figure. This is because of the waste heating value being so widely variable from what was expected and the wide swings in ash content. Recent studies made for the Ontario MOE have confirmed what we were finding out on a day by day basis. This lower through-put has resulted in lower gas flow into the afterburner and thus mixing was not what it should have been. Physical modifications to the afterburner chamber have corrected this.

We have also had much trouble with air injection ports in the primary chamber plugging with liquids from the charge. A re-distribution of some of this air has been necessary. The ash problem has necessitated being able to physically prod the ash collection zone to prevent build-ups.

Other changes and corrections have included re-location of control thermocouples and water sprays, adding water sprays in the ash receiving area, and strengthening the charging door seal and hydraulic actuator cylinder.

CONCLUSIONS:

Incineration is a complex combustion process, even when everything is working well. What we have tried to describe are 3 examples that work. Others could quickly give you other examples. There are in fact hundreds of incineration systems for hazardous wastes which work. The technology is out there -- use it.



Sub-X[R] Incinerator for Chlorinated Liquids

Fig. 1

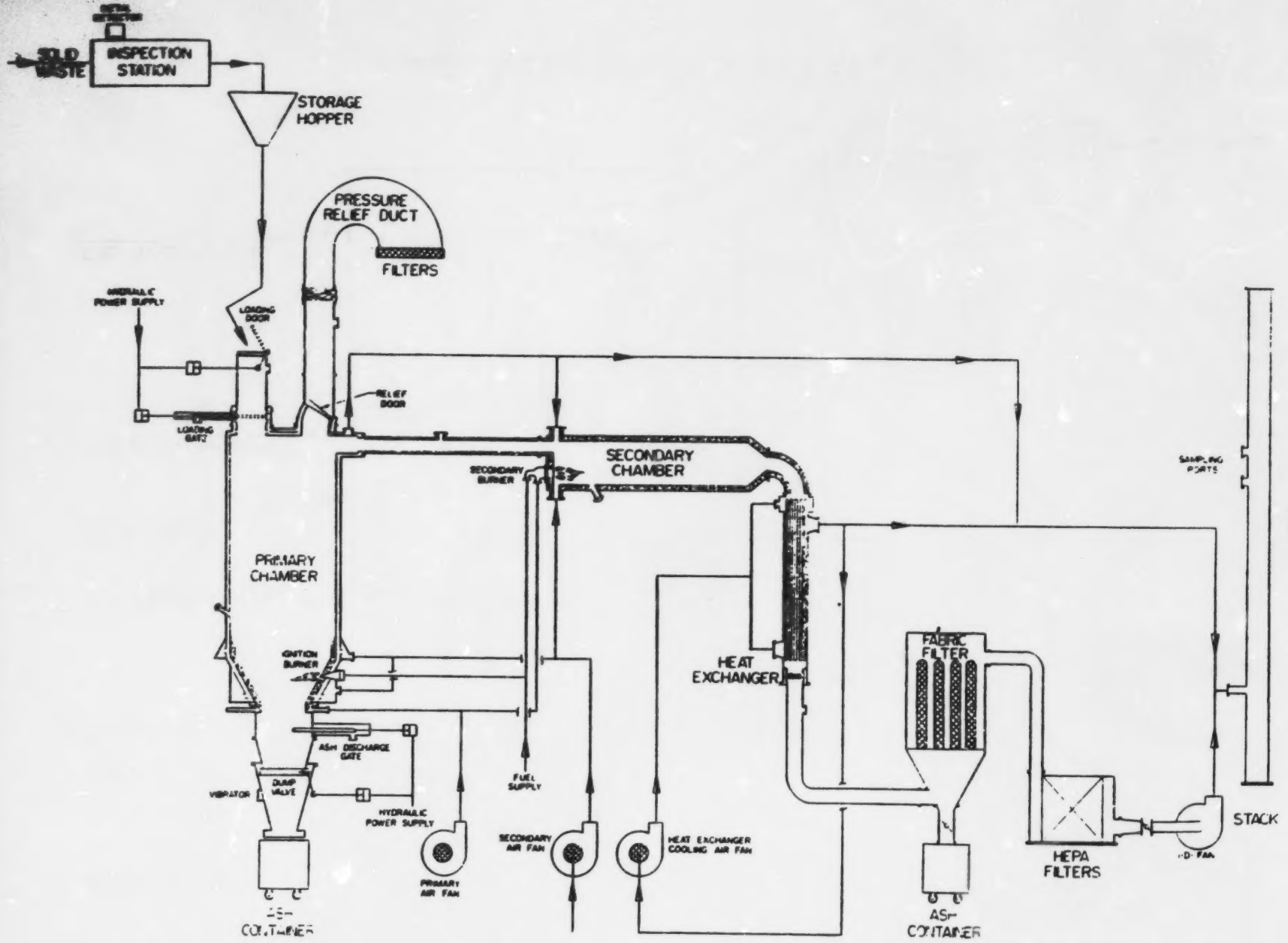


fig 2- INCINERATOR SYSTEM SCHEMATIC

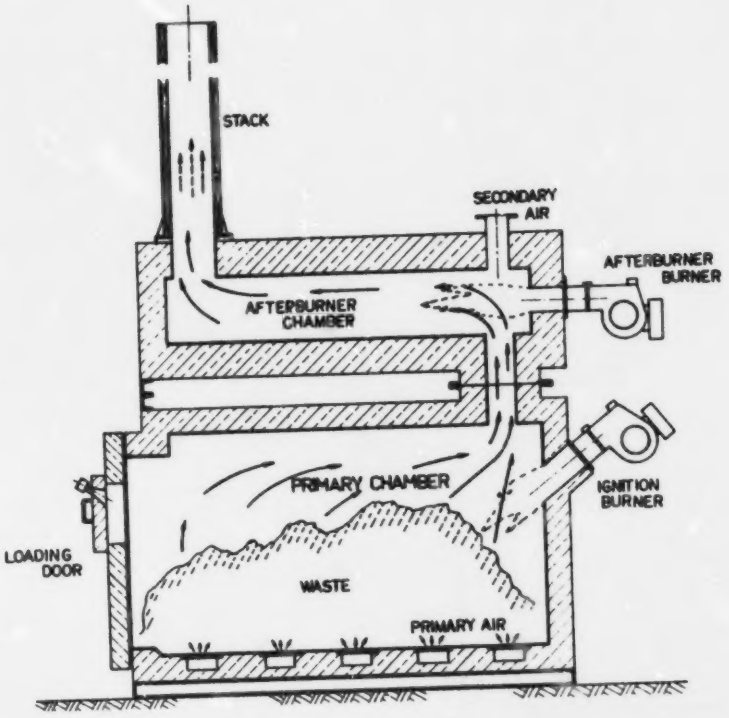
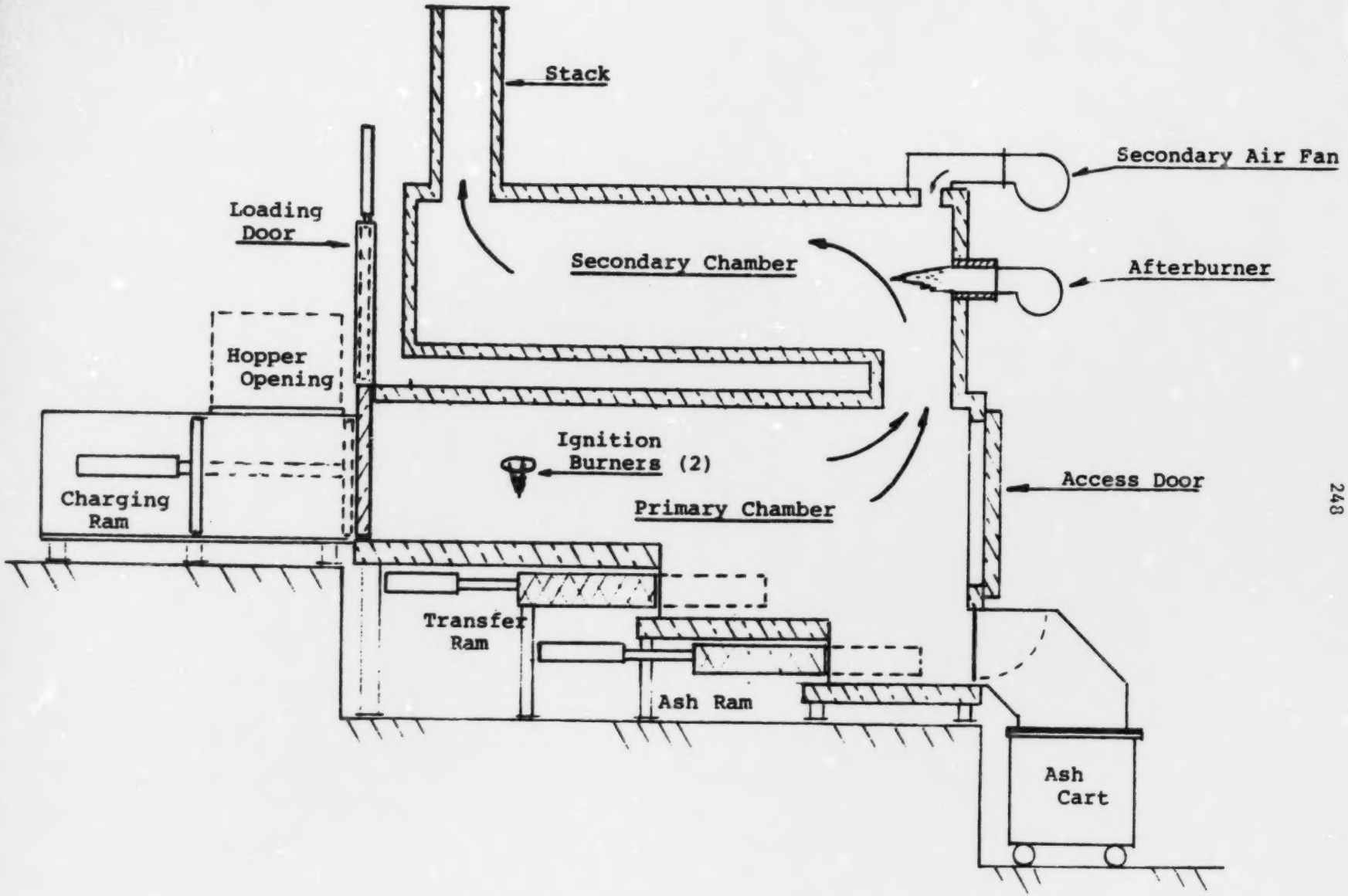


Fig. 3 CONTROLLED AIR INCINERATOR FOR SOLID WASTES



SEMI-CONTINUOUS SOLID WASTE INCINERATOR

Fig. 4

INCINERATION OF HAZARDOUS WASTES

Charley Robertson

ENSCO

Paper unavailable at time of printing

THE NATIONAL INCINERATOR TESTING AND EVALUATION PROGRAM
Two-stage Incinerator Combustion Tests

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Background

In Canada, as in the rest of the developed world, alternative techniques other than landfilling, for disposal of municipal solid waste are being developed and implemented. Energy from waste with the dual advantages of waste reduction and energy generation seems to offer significant benefit. Against this benefit is the uncertainty of air emissions and the public concern about dioxin and other potential health and environmental effects. In response to these issues, Environment Canada established the National Incinerator Testing and Evaluation Program - NITEP.

NITEP Objectives

The objectives of NITEP are as follows:

- To define the optimal design and operating characteristics of three generic municipal incinerators in order to minimize both toxic and conventional emissions of concern;

- To establish a matrix, relating operating conditions to emissions for each generic design through a comprehensive test program:

- To investigate both alternative combustion and emission control technologies, and identify the best practical control options;

- To provide the design and operating guidelines for future incinerator applications;

- To develop and employ internationally recognized protocols for sampling and analysis of dioxins, furans and other pollutants, and

- To determine if surrogates exist for dioxins that can be readily and inexpensively monitored.

Selection of Test Sites

From an assessment of projected future trends in incinerator technology in Canada, three generic designs were identified for the testing program. These are the two-stage combustion system, the mass burning system and the prepared burning system. The first candidate facility selected was the two stage combustion facility in Parkdale, Prince Edward Island owned by the PEI Energy Corporation and operated by Tricil limited of Mississauga, Ontario.

P.E.I. Incinerator Description

The Parkdale EFW facility operates three 33 tonnes per day air-starved dual-chamber incinerators. These incinerators are connected via a common manifold to a boiler, which is a two drum type with a close-spaced full water tube boiler bank. Combustion gases flow through the boiler in a single pass parallel to the axis of the boiler drums. Low pressure steam (1965 kPa) from the boiler is furnished to a nearby hospital.

An economizer located at the outlet of the waste heat boiler is used to heat the feedwater. From the economizer, the flue gases are drawn through the ID fan into the stack. There are no emission control devices.

Ash from the primary chamber is discharged into a common water filled quench tank equipped with a submerged hood. Fly ash accumulated in the boiler and economizer is collected and disposed of with the bottom ash.

The facility normally operates two incineration units with the third as a standby for peak loads. Refuse feed rate to each unit is approximately 1600 kg/hr. Charge interval (normally 8 minutes) and load size are varied to control the primary temperature at 620-730°C. Primary air is provided at low velocity into the lower portion of the fuel bed at substoichiometric levels. Combustible gases and any entrained particulate material leave the primary chamber and enter the secondary chamber where they are mixed with preheated secondary air to complete the combustion. Secondary chamber temperature is controlled at approximately 1000°C by increasing or decreasing the secondary combustion air supply.

Test Program Description

The test program for the Parkdale EFW was the most thorough and extensive ever under taken. In order to ensure that these tests were conducted in a manner which covered the full practical operating conditions of the facility, a two phased approach was used. The first phase was a series of twenty-two characterization runs to establish the signficance of key variables of incinerator operation. From this series of tests, four specific conditions were established for the extensive performance assessment. These conditions are shown in Table 1. Each test condition was repeated three times.

A summary of the parameters to be measured under each performance test are shown in Figure 1.

For the ash component, primary chamber bottom ash, the boiler ash and the economizer ash were each measured. For all ash samples, the concentration of approximately 30 metals was determined from which 6 metals are prioritized in figure 1.

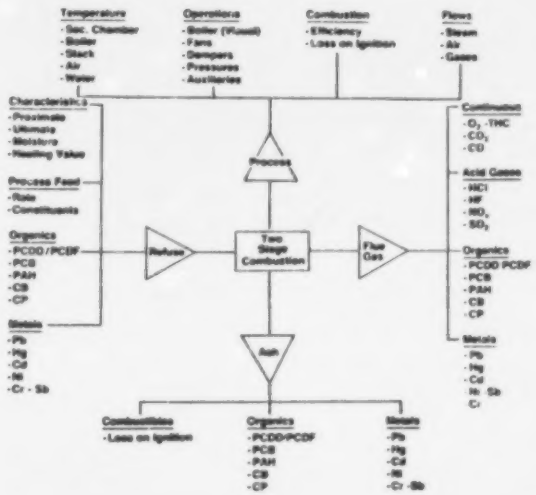
TABLE 1 PERFORMANCE TEST CONDITION SELECTIONS AND SETTINGS

Condition	Settings: Primary Temp. °C	Settings: Secondary Temp. °C*	Settings: Feed Cycle Min.	Rationale
Normal Operation	700	1000	8.7	Benchmark for comparison with other tests
Long Feed Cycle	700	1000	12.5	Observed improvements in performance and reduced demands on plant loader operator
High Secondary Temperature	700	1135	8.7	To determine influence of high temperature on organic emissions such as dioxins and furans
Low Secondary Temperature	700	900	8.7	To investigate a condition which was thought to create higher organic emissions

* Control Panel Settings

FIGURE 1

PERFORMANCE TESTING SUMMARY



Significant attention was paid to the establishment of sampling and analytical protocols for the program. Extensive discussions were held with the U.S. Environmental Protection Agency, the ASME and the Ontario Ministry of Environment to ensure that the best procedures were followed. In addition, a rigorous quality control/quality assurance program was established.

Over 30 engineers and technicians were involved in performance testing. Ten sampling/monitoring locations were utilized and included seven manual stack sampling trains (six on the stack and one preceding the boiler), nine continuous gas monitors and over 30 thermocouples. Over 1000 analyses (Figure 2) were carried out, including 380 for dioxin/furan, on the samples collected.

FIGURE 2

ANALYTICAL SUMMARY

• PCDD / PCDF	380
• PCB / PAH / CB / CP	290
• COMBUSTIBLES	150
• METALS	120
• ORGANIC SCREENING	26
• TO_x	26
• ACID GASES	26
• PARTICULATE CONC.	13
• PARTICLE SIZE	13
• ULTIMATE ANALYSIS	13
TOTAL	1057

Test Results

An examination of the individual data readings for the three test runs conducted at each of the four conditions shows that good consistent operational control was maintained. For example, the primary temperature was controlled within an operating band of ± 40°C and the secondary temperature ± 10°C. A summary of key operating parameters is shown in Table 2.

TABLE 2

SUMMARY OF KEY OPERATING PARAMETERS

Operating Conditions	Normal Condition	Long Cycle	High Secondary Temperature	Low Secondary Temperature
Primary Temperature (°C)	695	690	703	676
Secondary Temperature (°C)	910	890	1080	780
Steam Rate (kg/h)	4360	4020	4470	3960
Refuse - Rate (kg/h wet)	1590	1600	1700	1520
- Calorific Value (kJ/kg as fired)	10 530	10 220	10 430	10 770
- Moisture (%)	35	35	32	35
- Non-combustibles (% dry basis)	14.0	13.9	15.0	13.0
Energy Input (kJ/h) x 10^6	16.8	16.2	17.6	16.0
Efficiency (%) - Input/Output	59.6	56.6	58.4	55.9
- Heat Loss	52.0	50.9	58.1	50.7

In order to compare the results from each of the four conditions, the three test runs for each condition were averaged. The stack emission data for some of the key parameters is presented in Table 3.

TABLE 3

COMPARISON OF EMISSIONS DATA

Contaminant	Stack Concentration (at 12% CO_2) Dry			
	Normal	Long	High	Low
TSP (mg/Nm^3)	208	230	247	167
HCl (mg/Nm^3)	1 085*	1 070	1 165	950
PCDD (ng/Nm^3)	107	107	62	123
PCDF (ng/Nm^3)	143	156	95	98
PCB (ng/Nm^3)	801	58	0	126*
PAH (ng/Nm^3)	7 005	8 010	6 653	12 490*
Chlorophenol (ng/Nm^3)	4 346	3 773	2 706	6 591*
Chlorobenzene (ng/Nm^3)	4 321	3 161	3 968	4 884*
Cadmium (mg/Nm^3)	0.9	0.8	0.8	0.6
Lead (mg/Nm^3)	13.5	15.2	15.2	8.4
Chromium (mg/Nm^3)	0.04	0.03	0.1	0.03
Nickel (mg/Nm^3)	0.2	0.3	0.5	0.5
Mercury (mg/Nm^3)	0.7	0.5	0.9	0.5
Antimony (mg/Nm^3)	0.6	2.6	0.5	0.5
	Stack Emissions per tonne of Feed (as fired)			
TSP (g/tonne)	843	874	977	682
HCl (g/tonne)	4 400	4 130	4 480	3 930
PCDD (mg/tonne)	428	400	228	516
PCDF (mg/tonne)	570	574	340	411
PCB (mg/tonne)	3 413	245	0	574*
PAH (mg/tonne)	29 305	33 201	26 956	54 514*
Chlorophenol (mg/tonne)	18 403	15 042	10 814	28 973*
Chlorobenzene (mg/tonne)	18 014	12 807	16 061	22 045*
Cadmium (g/tonne)	3.8	3.0	3.2	2.6
Lead (g/tonne)	54.8	57.8	60.0	34.2
Chromium (g/tonne)	0.2	0.1	0.4	0.1
Nickel (g/tonne)	1.0	1.0	2.2	1.9
Mercury (g/tonne)	2.8	2.0	3.6	2.2
Antimony (g/tonne)	2.3	9.6	2.1	1.9

* based on average of two tests only

A cursory examination of this information suggests that there were no extraordinary differences between the emissions under the four test conditions. It does suggest however that operating temperatures are an important consideration. The organic emission rate is highest at lower temperature, while the metal emission rate is lowest. Similarly the organic emission rate is lowest at the higher temperature, while the metals are higher. This must be considered in establishing the facility design and operating criteria.

A closer examination of the dioxin/furan data in terms of homologue distribution is given in Figure 3 and Figure 4.

FIGURE 3

STACK DIOXIN HOMOLOGUE DISTRIBUTION BY TEST CONDITION

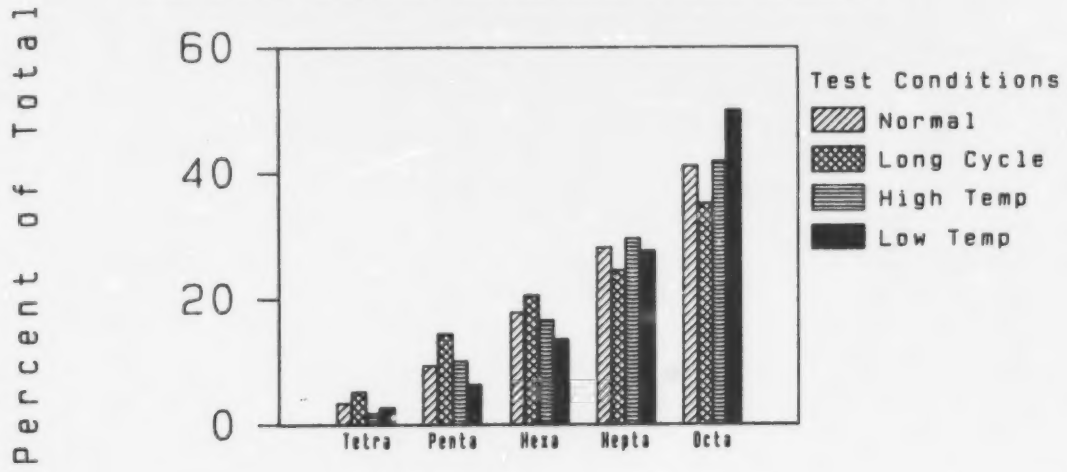
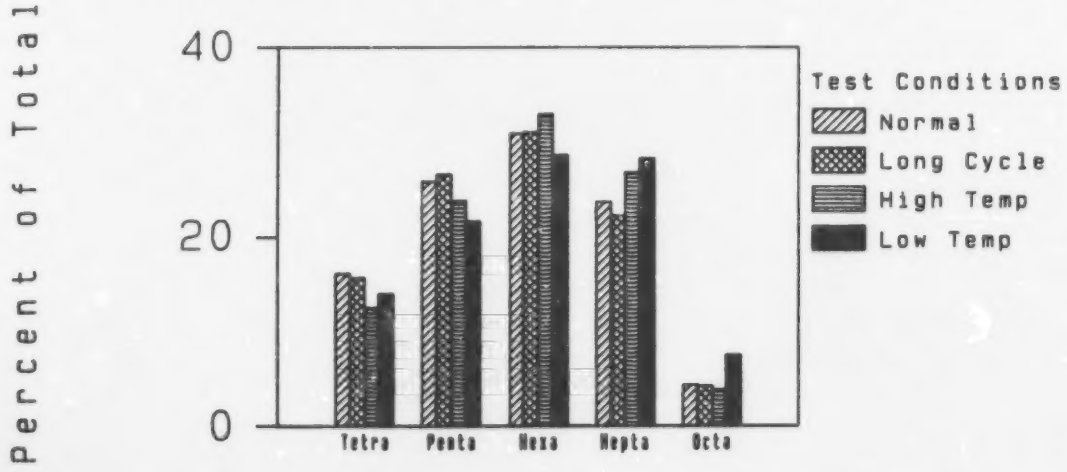


FIGURE 4

STACK FURAN HOMOLOGUE DISTRIBUTION BY TEST CONDITION



Once again it is evident that the respective amount of each homologue of dioxin and furan does not differ significantly between test conditions. A summary of the average homologue distribution for all the data is shown in Figure 5.

For three of the four test conditions, combustion gases at the inlet to the boiler were sampled for organics. The analysis of these samples (three test runs for each condition) is summarized in Table 4 and compared to stack organic analysis. There are signficant differences between results from these two locations, which suggest some form of gas transformation occurring through the boiler.

FIGURE 5

STACK DIOXIN AND FURAN HOMOLOGUE DISTRIBUTION

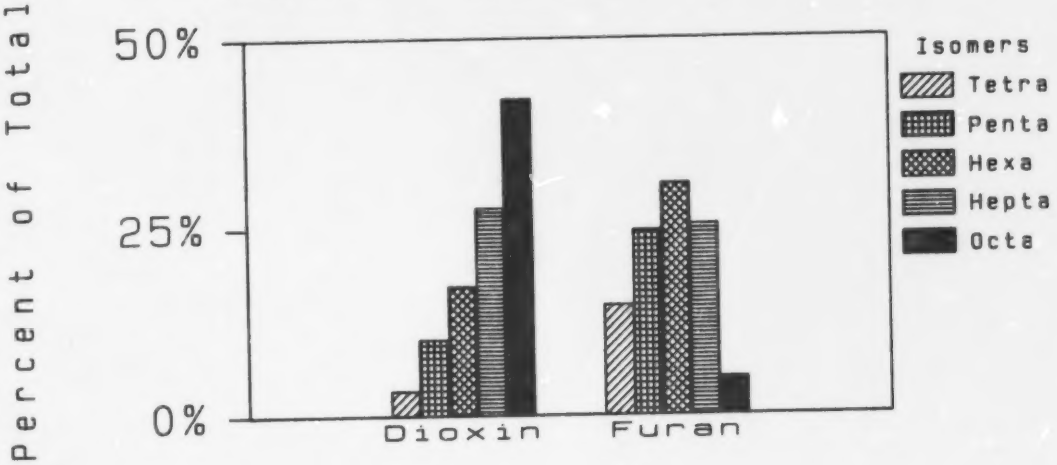


TABLE 4

CONCENTRATIONS OF ORGANIC COMPOUNDS AT BOILER INLET IN COMPARISON TO STACK

	Concentration (ng/Nm^3 @ 12% CO_2)					
	Long Cycle		High Temperature		Low Temperature	
Compound	Boiler Inlet	Stack	Boiler Inlet	Stack	Boiler Inlet	Stack
PCDD	0	107	1	62	14	123
PCDF	0	156	0	95	10	98
PCB	11*	58	8*	0	61	126**
PAH	10 475	8 010	12 226	6 653	29 481	12 490**
Chlorophenol	486	3 773	479	2 706	2 941	6 591**
Chlorobenzene	6 595	3 161	4 895	3 968	8 906	4 884**

* only one non-zero value (two readings were below detection limit)
** based on average of 2 tests only.

To complete the dioxin picture, Table 5 has been prepared showing the respective amounts of dioxin in the feed refuse, the bottom ash, boiler ash, economiser ash and the stack. The homologue distribution for each location is shown in Table 6. It should be noted that no dioxin was found in bottom ash.

TABLE 5

DIOXIN MASS INPUT/OUTPUT
Based on 12 Test Run Average

	SAMPLE ORIGIN			
DIOXIN	REFUSE	BOILER ASH	ECONOMIZER ASH	STACK EMISSIONS
(mg/h)	4.8	0.22	0.016	0.64

Note

Refuse input and stack outputs are based on actual measurements, whereas ash dioxin outputs are based on actual concentration and conservatively assumed ash production rates.

Assumptions

1. 90% reduction of Refuse on a weight basis for total ash.
2. Incinerator Bottom Ash is approx. 98.5% of total ash.
3. Boiler Ash is approx. 1.25% of total ash.
4. Economizer Ash is approx. 0.13% of total ash.
5. Based on average feed rate of 1.6 tonnes/h.

TABLE 6

DIOXIN HOMOLOGUE DISTRIBUTION

Based on 12 Test Run Average

ISOMER	SAMPLE ORIGIN			
(% of total Dioxins	REFUSE	BOILER ASH	ECONOMISER ASH	STACK EMISSIONS
TETRA	5	43	2	3
PENTA	19	18	5	10
HEXA	12	16	17	17
HEPTA	13	6	25	28
OCTA	51	17	51	42

To complete the picture on other organics, Figure 6 has been prepared showing the emission factors for chlorobenzenes (CB), polychlorinated biphenols (PCB), polycyclic aromatic hydrocarbons (PAH) and chlorophenols (CP). Figure 7 shows the concentration in the various solid streams.

FIGURE 6

TOTAL ORGANIC EMISSION FACTORS

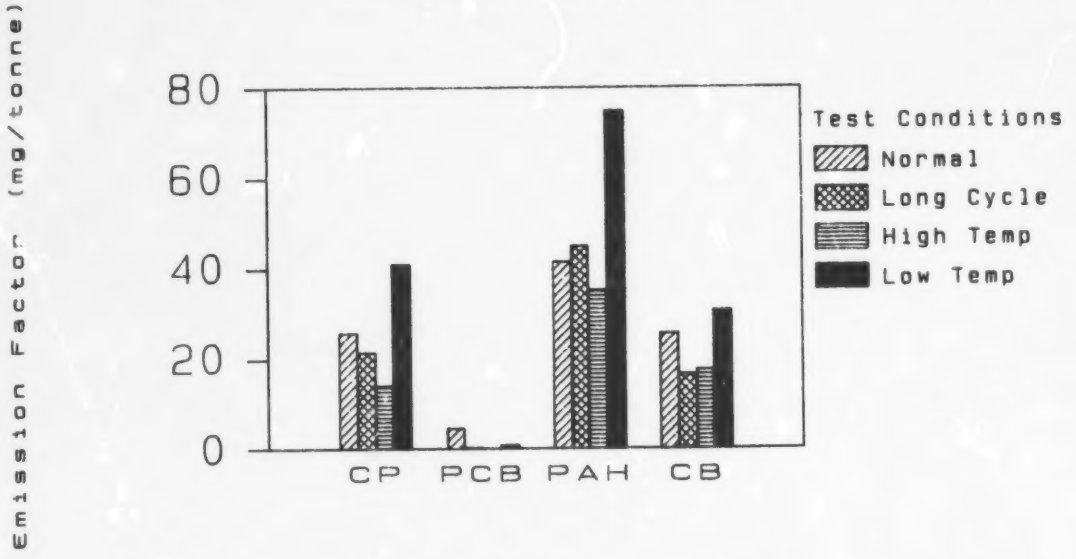
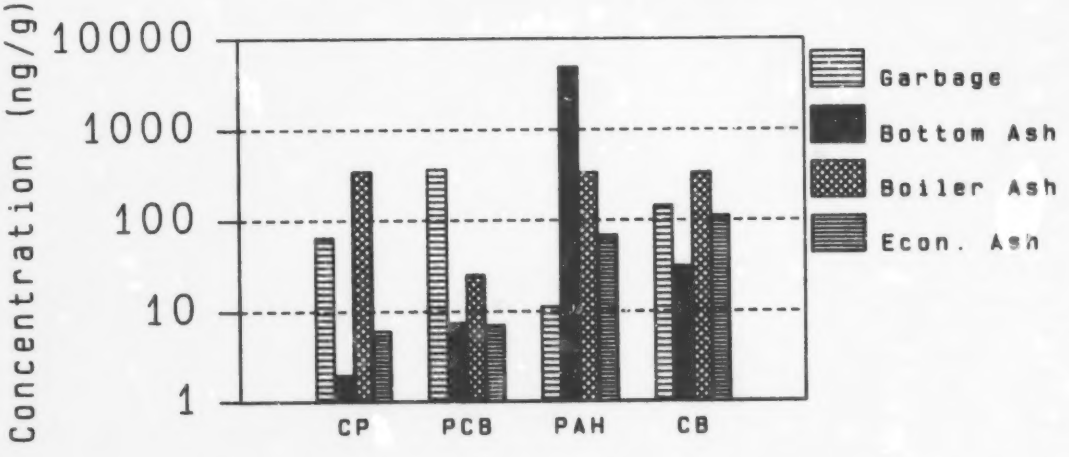


FIGURE 7

DISTRIBUTION OF ORGANICS IN SOLIDS



With respect to metals, Figure 8 provides the emission factor while Figure 9 gives the concentration in the solid streams. Since some larger metallic objects were removed from the garbage sample in the sample preparation phase, no data is provided.

FIGURE 8

SELECTED METAL EMISSION FACTORS

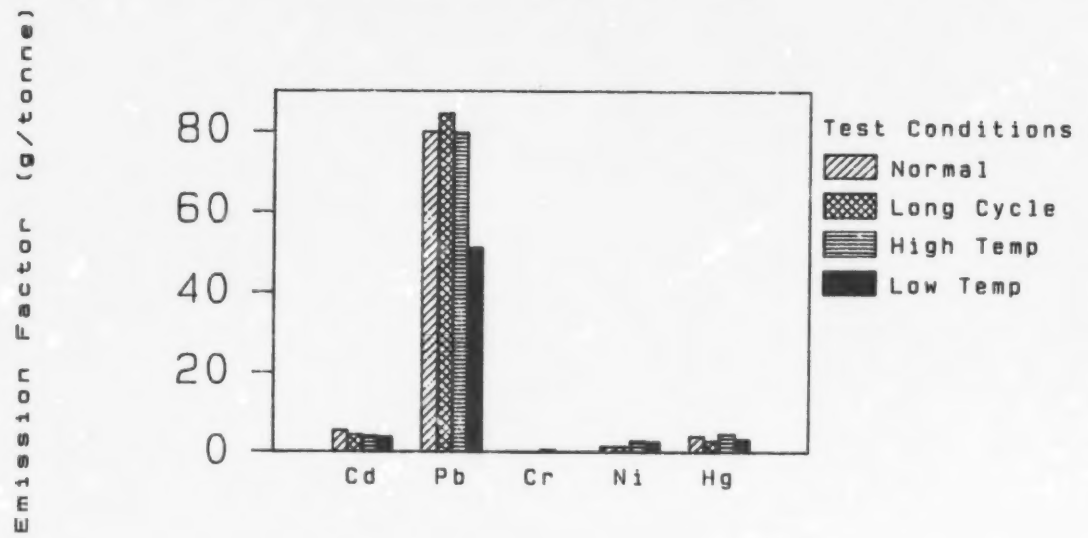
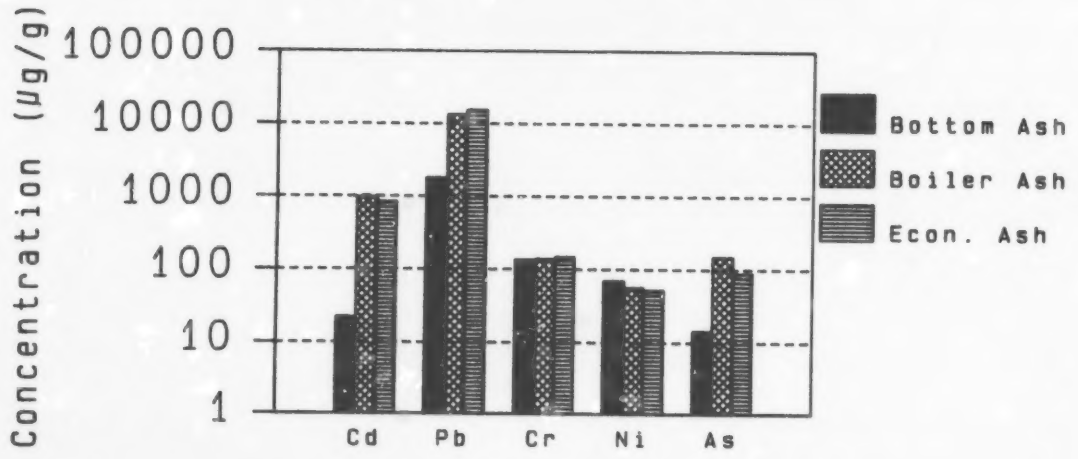


FIGURE 9

DISTRIBUTION OF SELECTED METALS



Conclusions

Although a significant amount of assessment of the data from this first test program remains to be done, several observations can be made, as follows:

1) Stack emissions factors for dioxins/furans were within the lower range of previously published values.
2) A relationship was found between dioxin emissions and secondary chamber temperature.
3) No evident precursor could be identified for dioxins/furans from such data as refuse chlorine content. However, these data were limited, since only one analysis of a composite refuse sample was completed per test run.
4) The range of low values recorded for carbon monoxide and total hydrocarbons (characteristic of good combustion) limited their use as surrogates for dioxins/furans. However, the low CO/THC values are associated with relatively low levels of dioxin/furan emissions. Therefore, it appears that low CO/THC levels could be indicators of low dioxin/furan emissions.
5) Because little published data on emissions of the other organic compounds from combustion sources were available, it is difficult to place these emissions into perspective.
6) Hydrogen chloride emissions were typical of uncontrolled emissions measured at other energy-from-waste facilities.
7) Particulate emissions were relatively low in comparison to uncontrolled emissions from conventional (mass burning) energy-from-waste incinerators.
8) A direct relationship was found between certain metals emitted from the stack and secondary chamber temperature. There also appears to be a potential trade-off between decreasing organic emissions and increasing metal emissions by varying combustion conditions.
9) Compared to stack emissions, the levels of dioxin and furan measured at the boiler inlet were significantly lower, virtually below the detection limit for some test runs. Conversely, the concentrations of polycyclic aromatic hydrocarbons were found to decrease across the boiler. This suggests possible chemical transformations occurring due to cooling.
10) The range of operating conditions under which the unit was tested represents the practical operating window for the two-stage system. No substantive differences in emissions were found over this range. Therefore, it appears that good design and proper operation, as observed for the PEI energy-from-waste facility, can minimize emissions of concern.

Other NITEP Tests

A combustion test program is planned for a mass burning system and will begin in March 1986. A report of these results will be available towards the end of 1986.

Although the EFW facility in Parkdale PEI meets all criteria for emissions, with the occasional exception of HCl, it is anticipated that future facilities of this type in other locations may require some form of emissions control. To this end and as part of NITEP, Environment Canada in cooperation with Flakt Canada have undertaken extensive testing of a pilot scale emission control system installed in Quebec City. The pilot plant consists of a dry lime reactor, as well as a spray type wet/dry reactor, followed by a fabric filter dust collector. Testing was completed in September 1985 and results will be reported in May 1986. This effort was even more extensive then the Parkdale project and will contribute significantly to the understanding of the effectiveness and limitations of this control technology.

The authors on behalf of Environment Canada would like to thank the many organizations and individuals who helped in the test program.

Reference: Report EPS 3/UP/1 - "The National Incinerator Testing and Evaluation Program: Two-stage Combustion (Prince Edward Island)"

PUBLIC COMMUNICATIONS INVOLVING THE PRIVATE SECTOR

Robert J. Redhead

Tricil, Ltd

(RESUME/ABSTRACT)

The Canadian public is being bombarded by news of chemical dangers almost daily through the print and electronic media.

From the waste management perspective, is the public getting the information it needs to fully participate in the public policy development process? This paper examines some of the conventional wisdom which has grown up around the management of chemical waste by the private sector, government's role and the public's responsibility.

The paper discusses new legislative initiatives, their likely effect on industry, and the need for public education to support these new directions in environmental protection.

TECHNOLOGIES FOR MANAGEMENT OF INDUSTRIAL WASTES

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INTRODUCTION

Throughout North America the control of hazardous wastes has been a priority issue for nearly a decade. The scope of the problem is broad. The need for long-term solutions that are protective of public health and the environment is urgent. These controls are implemented through a variety of laws. Some of them are implemented through regulation of hazardous waste management activities. Others are managed through legislation directed at preserving natural resources: air, water and special ecosystems.

The words chemical and wastes are viewed by society as being directly associated with damage, death and horrible diseases. Yet, everything surrounding us is composed of chemicals. Both natural and man-made processes have the potential to generate hazardous wastes. For example, natural degradation processes can release hazardous compounds and elements into the environment.

A variety of societal activities also result in the generation of hazardous substances. These include manufacture of common goods, the production of heat and electricity, production of food, and transportation of people as well as products. Every activity in which an individual engages during a normal day has the potential to generate and release some hazardous substances into the environment. The degree of potential hazard varies depending on the activity. Thus, as our populations and their expectations for high standards of living increase, so does the potential for generation of hazardous waste.

Proper waste management is fundamental to man's well-being. Although the ideal situation is to destroy totally hazardous substances, this is not always possible. It is important to emphasize that all substances consist of combinations of atoms (i.e., elements) and molecules (i.e., compounds) bound together through chemical or physical processes. Organic substances are composed of compounds that can be broken down to simple elements by applying various treatment processes. Inorganic substances generally are composed of combinations of elements. These combinations can be rearranged, but they cannot be destroyed. Thus, while the magnitude of hazards associated with these substances can be reduced, they can not disappear totally.

Proper management of waste then necessitate developing a combination of options that results in the highest level of protection possible for public health and the environment. In the past, disposal in land has been the primary option for managing industrial wastes. In some cases this option was preferred due to lower management costs. However, for other wastes, no alternatives existed. However, today it is apparent that this option is not a permanent, nor always desirable, solution. Thus identifying alternatives to

land disposal has been a major focus of management activities everywhere.

This paper provides an overview of technologies for managing waste. Currently available treatment alternatives and promising new developments are discussed. Research needs are identified. Potential constraints on to commercial development of new alternatives are highlighted.

COMMERCIALLY AVAILABLE ALTERNATIVES

The actual effectiveness of any management option will depend on the properties of the constituents and the limits of the process application. No one technology (be it treatment or disposal) is a panacea for proper management of the diverse range of industrial wastes existing today. Most treatment technologies generally control either organic constituents or inorganic elements. Rarely is one technology effective for both organics and inorganics.

For example, appropriate technologies currently exist to treat a wide variety of previously recalcitrant organics. The constraint in applying any one in a management strategy is not technological but actually economic. The high cost required to implement advanced treatment technologies reduce their widespread use as alternatives to land disposal. Inorganic elements in wastes pose somewhat more difficult management problems. Management options for these constituents are limited to those treatment processes that render the individual constituents immobile, allowing the residues to be placed safely in the land.

There are five major types of treatment alternatives practiced by the hazardous waste service industry today. These include physical, chemical, biological, thermal and stabilization/solidification treatment processes. The actual application of any one, or any combination of the five, depends on characteristics and properties of the waste (i.e., is the waste solid or liquid, concentrated or dilute containing organics or inorganics?). A review conducted by Mackie and Niesen indicates that there is a diverse range of commercial treatment options. (Mackie and Niesen, 1984) Table 1 illustrates some typical applications. It must be emphasized that all of these treatment processes generate a residue that may be of lesser, or greater, hazard potential and may be in volumes greater than the original waste. These residues can only be land disposed.

Physical Treatments

Physical treatments only separate various phases of the waste (e.g., liquids from solids) and, in general, concentrate hazardous constituents in solid or sludge phases. By concentrating the constituents, further treatment processes, or perhaps direct disposal, can be done more cost-effectively. Physical treatment alternatives include magnetic processes, liquid-solids separation, evaporation techniques, distillation techniques, solvent extraction, and membrane-separation techniques such as reverse osmosis and electrodialysis.

Chemical Treatments

Chemical treatments involve advanced chemical reactions that will either render the waste non-hazardous, (e.g., through neutralization) or completely degrade hazardous compounds (e.g., through hydration). The use of chemical treatments is not a new concept. The technical ability to chemically change

TABLE 1. EXAMPLES OF COMMERCIALLY AVAILABLE TREATMENTS

	Typical Applications
Physical	
Centrifugation	separates liquids and solids
Filter Presses	removes moisture from solids, sludges
Distillation	solvent purification
Carbon Absorption	removes organics
Reverse Osmosis	removes metals and organics
Chemical	
Precipitation	removes metals
Oxidation	destroys organics
Reduction-dechlorination	reduces chlorine content of hydrocarbons
Photolysis	destroys dioxin and cyanide
Biological	
Aerobic/Anaerobic	removes metals and organics
Land Treatment	degradation of organic sludges
Thermal	
Liquid Injection	destroys organics in liquid wastes
Rotary kiln	destroys organics in sludges and solids
Stabilization/Solidification	
Sorption	uses variety of material to solidify inorganic liquids (e.g., fly ash, lime, clays and carbon)
Pozzolanic Reactions	uses lime-fly ash or portland cement to solidify inorganic wastes.

industrial waste has been available for many years. Current innovation focuses primarily on new applications and on the development of more efficient uses of chemical reactions.

Commercial applications include oxidation-reduction reactions to degrade trace organics, photolysis to destroy cyanide and dioxin wastes, and precipitation of various metals. Major considerations in the use of these types of treatment processes are the potentially low solubility of some metals, impurities in the waste that can inhibit reaction, and potentials for generating equally hazardous by-products.

Biological Treatments

Biological processes have been used in public wastewater treatment systems for some time. These treatments can destroy completely or, at a minimum, reduce the hazardous concentrations within the waste. The limitation of these treatment applications, however, is in the presence of biodegradable constituents in a waste stream. Biological reactions are quite sensitive to the presence of toxic elements, either non-biodegradable organic compounds or metals.

Land treatment is another form of degradation used commercially for some hazardous waste, primarily refinery sludges. However, using this process, the potential exists for incomplete degradation by natural microorganisms and migration of hazardous constituents from the treatment site to groundwater sources.

Thermal Processes

Conventional thermal treatment processes (i.e., traditional incineration) are useful primarily for organic compounds. Thermal destructions usually involve combustion of organic material yielding carbon, oxygen, and water. These treatment alternatives can be quite efficient, but also very expensive by comparison with physical, chemical or biological processes. There are limitations in the fuel value of a waste and in operational conditions required for maximum destruction efficiency.

Stabilization/Solidification Processes

Stabilization/solidification processes are alternatives used for wastes containing inorganic elements. In contrast with chemical, biological and thermal treatments, there is no change in the toxic property of the hazardous constituent. However, the potential mobility of these constituents is reduced dramatically. Although these treatment processes are commercially available, new applications are being investigated. (See New Applications for Inorganics.)

NEW TREATMENT APPLICATIONS

The commitment by industry to find better methods for managing industrial wastes is apparent in the variety of patents being filed in the United States and the wide range of technology demonstration projects. Both manufacturing and waste-service industries are capitalizing on the need for new technologies. For example, Philips Petroleum has developed a process to purify used oil. Kerr-McGee in Oklahoma has a patent for recovery of organic solvents. IBM recently received a patent for treating liquid wastes containing copper ions and organic complexing agents. Critical Fluids, Inc.

has a patent for a critical fluid extraction process for separating organics from liquids. In addition, a broad range of technologies at varying stages of development focus on previously recalcitrant hazardous constituents. Examples of major types of new treatment developments are indicated in Table 2.

New Options for Organic Constituents

There are a variety of new technological developments for those organic constituents found in today's industrial waste. These include thermal destruction, photolysis, and advanced oxidation- reduction processes. More detailed descriptions of these technologies can be found in a 1985 issue of The Hazardous Waste Consultant. (Anonymous, 1985a)

Among thermal destruction options are improvements in conventional incineration technology as well as new thermal applications. For example, pyroplasma processes incorporate plasma arc technology operating at extremely high temperature (greater than 5600°C) to decompose complex organics. The basic principle of such applications is to produce a plasma of charged and neutral particles. As this plasma decays, hazardous organic constituents are decomposed. This technology is in early stages of development, but it has had some success in detoxifying chlorinated organics.

Circulating bed combusters use high turbulence to entrain constituents in a combustion chamber. The system is an improvement over conventional incineration as it operates at much lower temperatures (790-870°C). The high turbulence and the resulting effective heat transfer in the system design results in effective destruction of organic constituents.

High temperature fluid wall reactors are being evaluated for treatment of both finely ground solids (-100 mesh) as well as liquid wastes. At temperatures of 2200°C, hazardous organics are pyrolysed to very simple compounds. The reactor equipment is designed to withstand high temperatures and resist chemical attack by the possible presence of inorganic components. These inorganic components (e.g., clay and metal salts) are removed from the waste stream and incorporated into vitreous solid residues. Trial burns have been successful in destroying PCBs.

Photolytic reactions are being evaluated for efficiency of destruction for a variety of organics. UV photolysis has been tested for dioxin-contaminated liquids. The success of these tests have led to further research on applications of the technology to dioxin-contaminated soils. The experimental work in progress is evaluating the use of surfactants as an improved dioxin-solubilizing agent. Surfactants apparently increase the efficiency of dioxin destruction without development of harmful by-products.

New oxidation processes for the destruction of organics are being researched and improved. For example, super critical water oxidation is a promising cost-effective alternative to either incineration or carbon absorption for wastes containing organics. At temperatures of 400°C, organics can be oxidized spontaneously. A major advantage of this application is the ability to destroy very dilute aqueous organic wastes, those industrial wastes that have organic concentrations ranging from 1 to 20 wt%.

Wet-air oxidation is an appealing technology for treatment of mixtures of organic and inorganic waste, using the concept of thermal oxidation. This technique has been shown to be useful for dilute waste streams that cannot be economically incinerated or biologically treated. Although this technology

TABLE 2. EXAMPLES OF NEW TECHNOLOGICAL DEVELOPMENTS

UV Photolysis	Used to detoxify liquids containing dioxin, being developed for application on contaminated solids; dioxin mobilized by surfactants and subjected to UV photolysis; can reduce concentrations by 90 to 99%.
Pyroplasma Processes	Break-down of waste fluids to elemental constituents; being developed as a mobile unit; tested for destruction of chlorinated organics; low power consumption and rapid start-stop mode.
Plasmadust Process	Recovery of metals from iron and steel mill baghouse dust; reduces metal oxide to elemental forms; iron removed with molten slag; zinc and lead removed as gas; tests resulted in yields of 96% for iron, zinc, and lead.
Plasma Arc	Destruction of PCBs and PCB-contaminated equipment; destruction and removal efficiency of 99.9999%; possibility for metal recovery from molten slag
Circulating Bed Incineration	High heat-transfer and turbulence allow operation at temperatures lower than traditional incinerators; accommodates solid and liquid wastes; complete destruction of organics at relatively low temperatures; no need for scrubber system to remove acid gases; particularly cost-efficient for homogeneous wastes from oil and petrochemical processes.
High-temperature Fluid Reactor	Most suitable for contaminated soil; liquid Wall wastes require a carrier; pyrolyze organics to carbon, carbon monoxide and hydrogen; equipment not attacked by inorganic components; mobile units possible; reaches destruction efficiencies of 99.9999%.
Penberthy Pyro-Converter	Glass-melting furnace technology adapted for destruction of organics; suitable or liquids, vapors, solids and sludges; solid residues (inorganics) incorporated into glass matrix; current use for production of HCl and destruction of chlorinated organics, therefore RCRA regulations not applicable.

Pyrolyzing Rotary	Operates in oxygen-free environment and at lower temperatures than conventional kiln; produces gas suitable for energy recovery or further treated to recover condensed hydrocarbons; recovery of metals possible without volatilization; reduced need for air pollution control; need to verify destruction efficiencies of hazardous constituents.
Rollins Rotary Reactor	Suitable for viscous and high-solids content wastes; no need for supplemental fuel; reduced gas scrubbing requirements; high-transfer efficiencies may increase destruction efficiencies at lower temperatures.
Supercritical Water	Oxidize organics to carbon dioxide and Oxidation water; high pressure steam or electricity produced; inorganic salts precipitated; especially efficient with highly concentrated organic wastes; for water containing 10% organics, destruction efficiency greater than 99.99%; suitable for chlorinated solvents and PCBs.
Wet Oxidation	Suitable for dilute aqueous waste that cannot be incinerated or biologically treated; destruction efficiencies expected in range of 99% to 99.99%; oxidizes organics and inorganics; not appropriate for halogenated aromatics.
Vertical-tube Reactor	Adaptation of wet exidation into 1-mile deep well system; operates at lower pressure than conventional process; currently applied to municipal wastewater.

Source: The Hazardous Waste Consultant, "A Guide to Innovative Hazardous Waste Treatment Processes, "January/February, 1985, pp. 4-1 through 4-32.

has been used in municipal sludge treatment applications, new developments are being explored for application to industrial hazardous wastes.

A new variation on the wet-air oxidation technology is the vertical tube reactor. The vertical tube reactor uses one-mile deep multi-tubed wells as the means of generating excessive heat and pressure. Oxidation of hazardous constituents occurs as wastes are pumped through a reactive zone, extending from 246 to 1600 meters below grade. The oxidized waste residues are recovered by pumping the material back up through the well casing.

New Applications for Inorganics

Because inorganic elements cannot be destroyed, the reduction of hazard potential for these types of wastes has been a difficult problem. Although stabilization and solidification processes are not new technologies, improvements in these applications are being developed to produce solidified matrices that will not leach hazardous elements. (Anonymous 1985b) As was reported last year, the U.S. Environmental Protection Agency and Environment Canada have embarked on a joint project to test the integrity of several stabilized/solidification applications. (Porter-Cathcart, 1984) The goal is to identify appropriate processes for a variety of industrial waste streams.

New processes are being evaluated for more efficient recovery of metals. One such application is a plasma dust process that recovers metals from waste dust generated by pollution-control equipment. Plasma generators supply sufficient heat to reduce any metal oxides in the waste dust. Iron particles melt and are removed along with molten slag. Zinc and lead elements are reduced and removed as metal vapors.

Pyro-converter technology adapts glass-melting techniques to the solidification of hazardous inorganic constituents. This technology has some promise for stabilizing mixed waste (those containing both inorganic and organic constituents). In this process, organic constituents are volatilized and pyrolyzed. Inorganic elements are trapped in molten glass. The glass residue then can be disposed safely in landfills.

Mobile Systems

Mobile treatment systems are gaining recognition throughout North America. They were first considered for remedial actions. However, other applications for contracting and services directly at generator facilities are also possible. For example, there is a mobile incinerator that is capable for reducing PCBs and dioxins in waste. Sophisticated mobile treatment systems are being developed. (For example, see Hemmerle, 1984.) These mobile systems provide a variety of treatment capabilities: carbon absorption, filtration, dewatering and decontamination. The attractiveness of such systems are that high capitol investments are not required of generators for on-site treatment of their wastes.

Residue Disposal

All technologies used to treat hazardous constituents in industrial wastes will produce some amount of residue. The hazard potential of these residues vary depending on properties of the constituents and on the destruction or immobilization efficiencies of the particular treatment process. Much as government officials and the public would like to believe that with just the right treatment hazardous constituents will disappear, real world results are somewhat different. Often residues from treatment processes

do contain hazardous compounds and elements and in concentrations higher than the original material. The only option available for management of these residues is their placement either in the ocean or in/on the land.

Ocean disposal, defined as placement of wastes in deep marine sediments, is highly undesirable. Our wealth of knowledge about these environments is extremely sparce. Our ability to predict the future, long-term integrity of either a particular marine site or ocean-disposal containers is minimal. Thus, in reality, only one option is available for residue management -- the disposal of waste materials in secure as possible land-disposal facilities.

Disposal options are often broadly defined to include long-term storage below ground and above ground in a variety of facility designs. Some also can include incorporation of residue into construction materials. For example, the incorporation of treatment residues into brick and cement-like materials. However, the potential use of these materials in construction of buildings, roads, or parking facilities is yet to be fully evaluated. More data are needed about the long-term security of the compounds and elements within such matrices. Further research is needed on the leachability of hazardous constituents from such products under normal use conditions.

Below-ground disposal is an ever-changing art. In the United States, the technology has changed from using thick impermeable clay-liners to government requirements for a facility that incorporates multiple liners (combinations of synthetic and clay liner material) and leachate collection systems between these liners. Unfortunately, the development of these new land-disposal designs does not reflect the expected changes in the types of wastes or treatment residues that will be placed in them. For example, the waste service industry no longer places bulk liquids in a hazardous waste landfills. By 1986, no containerized-free liquid will be allowed.

In addition, our industry expects restrictions of most organic wastes in land-disposal facilities. By the 1990s, the only wastes permitted in such facilities likely will be inorganic or treatment residues. These residues may have some organic constituents, but in only trace concentrations. Given these developments, it has been speculated that our current government requirements for design of a multi-liner facility may be "overkill". Consideration of location characteristics suggest that multi-liners may not be required in all situations to insure a secure and protective environment.

Above-ground disposal is a somewhat new concept. (CECOS International, 1985; Rollins Environmental Services, 1984.) Basically, this system is quite similar to a below-ground design. The important major difference, however, is that the facility is constructed above grade. Thus, there should be less likelihood for contact of leachate generated within the facility with groundwater or aquifer sources below ground. The use of above-ground storage has been suggested for a variety of materials including treatment residues contaminated soils and contaminated equipment. Depending on the design, such facilities could serve as storage sites, until appropriate full-destruction or recovery technologies are developed for recalcitrant hazardous compounds and elements.

FUTURE RESEARCH NEEDS

The development of appropriate treatment and disposal options requires continued applied research activities. Many of the options presented in the previous section are not yet ready for commercial application. Fine-tuning is

needed for some; more extensive research of appropriate application for a variety of waste streams are required for others.

Basic Research

Basic research still is needed in several areas. For example, waste containing mixtures of organic and inorganic constituents currently are very difficult to treat. Concentrations of organic components in mixed wastes can inhibit stabilization/solidification techniques. Inhibitory concentrations generally range between 5% and 25% organics. Incineration of metal elements found in mixed wastes is not possible. Our ability to separate organic and inorganic components of a waste is not as efficient as one might desire.

The ability to treat and destroy liquid wastes containing halegonated organics is currently available. Incineration is the most effective strategy, in spite of its high cost. However, our ability to treat halegonated sludges or solids is much more constrained. New research, some of it basic research, is required for more effective management of solids containing these compounds.

Another area demanding basic research is the destruction of trace amounts of hazardous constituents within waste or contaminated materials. Trace amounts are defined in ranges of parts per billion or lower. As analytical detection in these low ranges improves, public pressures will focus regulatory attention at these levels. Yet, our technological capability to remove and destroy hazardous constituents at such levels is not highly efficient. Scientists within the waste-service industry have suggested that catalytic reactions must be developed for destruction of such trace amounts. Basic research in catalytic reactions is needed and soon to address this management issue.

New research directed at recovering metals in a cost-effective manner is desirable. The demand for this type of technology will increase for two reasons.

1) More stringent treatment standards for industrial wastewaters can be expected over the next few years. (Dilution of industrial wastewaters to meet discharge standards should not be considered a viable treatment option.)
2) More stringent regulations can be expected for land disposal of even treatment residues. Certain metal-bearing residues may not be able to meet these standards.

If new techniques can be developed for cost-effective recovery of metals from waste, then any potential for future health or environmental threat will be eliminated. Recycling of recovered materials is always a priority waste management goal.

As characteristics of waste destined for land disposal change, research will be needed to verify compatibility of new wastes with various land disposal designs. Research on liner and construction material compatibility for a variety of hazardous constituents is needed. More precise and accurate methods to predict leachate generation and movement within disposal designs will be helpful in developing a new generation of more secure disposal facilities.

Health Data

A major effort must be initiated to compile health-related data for the diverse range of constituents found in industrial wastes. Limited data are

available to evaluate potential exposures and actual damage to human health or the environment. Such data are vital for establishing regulatory standards for new treatment technologies.

To date, there is virtually no evidence that the public health has been damaged as a result of waste management options. (URAEP, 1985) One cannot feel confident, however, that the lack of evidence means no damage has occurred. The studies of health and environmental damage directly related to hazardous waste instances are few in number. The existing data on individual waste constituents are insufficient for evaluating potential threats to health and the environment. First, we must begin to increase our knowledge about the potential for exposure resulting from treatment and disposal options. Second, we must develop a better understanding of the likely consequences of such exposures.

CONSTRAINTS FOR NEW COMMERCIAL CAPABILITIES

A major difficulty in implementing greater use of advanced treatment technologies in management strategies is the lack of commercial capacity. A U.S. Environmental Protection Agency 1981 survey emphasized that commercial capacity accounted for only 1% of the national total for these alternatives. (Westat, 1984) As illustrated in Table 3, the number of available commercial facilities in the United States alone is limited and not uniformly distributed throughout the country. The condition in Canada is similar. Although it is quite obvious that technologies can be commercially developed, several uncertainties must be resolved before substantial progress is evident.

Siting Problems

The inability to site a new facility is perhaps one of the major impediments in North America. The prevalent attitude by potential host communities is that any waste service facility is undesirable. Unfortunately the public has not been willing to acknowledge both the need for hazardous waste services and the differences in health and environmental risks associated with treatment technologies as compared to "old style" landfills. In the last two years, there have been 15 major attempts at new facility development in the United States. (Anonymous, 1985c) None have been successful. In Canada the acceptance of a site for the Ontario Waste Management Corporation has not been easy to obtain. It has required a three year process to choose a site. (Ontario Waste Management Corporation, 1985) Estimates of another 1½ years have been suggested for full evaluation of the selected site and an additional year to complete the public hearing process.

Permitting Process

In the United States a major impediment to development rests with the slow pace and established priorities of the permitting process. Before any management facility owner or operator, whether employing traditional or new technology, can engage in hazardous waste service activities, it is necessary to obtain a permit granted under federal or state programs. The record to-date for permitting is very poor. (Weddle, 1985) Of the facilities classified by EPA as storage/treatment facilities, only 363 of an expected 2392 facilities have received permits. The majority of these are for storage of hazardous waste rather than for actual treatment. Only 18 of the 236 potential incineration facilities have received final permits; few of these are commercially owned.

TABLE 3. DISTRIBUTION OF COMMERCIAL FACILITIES IN THE UNITED STATES

STATE	TREATMENT	INCINERATION*	DISPOSAL
Alabama	1	1	1
Arkansas	1	2	0
California	7	2	8
Connecticut	5	0	0
Florida	0	1	0
Georgia	1	0	0
Idaho	1	0	1
Illinois	6	2	6
Indiana	3	0	3
Iowa	1	0	1
Kansas	0	1	0
Kentucky	1	2	0
Louisiana	3	1	5
Maryland	1	1	0
Massachusetts	1	2	0
Michigan	9	0	1
Missouri	0	0	1
Nevada	0	0	1
New Jersey	3	3	2
New York	4	4	3
North Carolina	0	3	0
Ohio	10	4	5
Oklahoma	2	0	2
Oregon	1	0	1
Pennsylvania	8	0	5
South Carolina	1	2	1
Tennessee	2	0	0
Texas	6	1	9
Utah	1	0	1
Virginia	0	2	0
Washington	3	0	0

* Many of these facilities have restrictions on concentrations and BTU value; includes cement kilns.

Source: The Hazardous Waste Consultant, "The Outlook for Commercial Hazardous Waste Management Facilities: A Nationwide Perspective," March/April, 1985, pp. 4-1 through 4-49.

Compounding the situation is the number of closures that are occurring as interim status expires. Recent summaries of the permitting program indicate a high rate of closures for all types of facilities. For example, by September of 1985, 892 storage and treatment facilities closed. Forty-two incineration facilities were closed along with 171 land disposal facilities.

Although the permitting and zoning activities in Canada are very different from the United States process, similar delays occur. The Canadian public hearing process can be used as a delaying tactic by groups opposed to new development or expansion. Regardless of the source of delays in permitting facilities, the result is the same -- constraints on expeditious development of advanced management options.

Market Availability

Availability of sufficient markets obviously impact the rate of commercial development. Three factors contribute to uncertainties about future hazardous waste markets. The first is the attempt by non-federal jurisdictions to restrict free transport of hazardous waste across borders. Throughout North America there are attempts to ban importation of hazardous wastes into states and provinces. Alberta is a prime example in Canada. From time-to-time voices on both sides of the border are raised to stop cross-border movements. Because of differences in the role of federal governments between Canada and the United States, outright bans on importation are prohibited as interfering with interstate commerce. However, restrictions on movement of waste between states can be accomplished through imposition of high taxes imposed on out-of-state wastes. In planning new commercial enterprises, there must be some certainty about the volume of waste that can be expected at a facility over time. If differentially tax rates exist, larger facilities, sometimes preferred because of economics of scale, will have a difficult time surviving.

A second, constraint can be differential tax rates imposed on wastes managed at commercial and generator-owned facilities. This is a practice gaining momentum primarily in the United States. Canada to date has taken a more even approach to generator and commercial facilities. Imposition of taxes only at commercial treatment facilities, on top of already high installing new technologies, places these facilities at a competitive disadvantage. The greatest potential for "new" technology development on a large-scale rests with the commercial industry due to requirements for large investment economies of scale. Because of low rates of return on such investment expected due to limited volumes generated by individual companies, generators are less likely to install more advanced treatment options. By imposing a high tax on only commercial facilities, a competitive disadvantage results between commercial and generator-owned facilities thus, impeding future commercial opportunities.

Third, the desirable goal for minimization of wastes by generators can result in some uncertainty as to the size of future markets as well as the composition of these wastes. Although minimization is desirable, it does have a direct impact on commercial development of innovative technologies. Until manufacturing processes have been identified and the volume and composition of future industrial wastes have been estimated, analysis of future market potential will be highly speculative. New investments are not likely until future trends can be identified with some certainty.

Some of these market vagaries can be reduced by equal enforcement of stringent regulation. This is particularly true when uniformity of regulations exist among states and provinces. For example, it is expected that with the passage of the Canadian Transport of Dangerous Goods Act greater definition of hazardous waste markets will be possible. In the United States, the uniform application of restrictions of certain waste in land disposal facilities should increase market potential for treatment and incineration alternatives.

Regulatory Impacts

Another uncertainty of particular importance to the development of innovative new technologies lies with potential regulatory requirements. Currently there are few standards for treatment processes other than incineration either in Canada or the United States. Potential developers are left to interpret or speculate either about

1) governmental interpretations of non-definitive regulations (as in Canada) or
2) future regulatory requirements (as in the United States).

Because the capital investment for scale-up and construction of new technologies will be very high, uncertainty about the acceptance of such technologies within a regulatory arena can delay necessary financial commitments.

Additional uncertainties about potential technical adjustments needed to meet regulatory requirements discourages acceptance of the innovative alternatives. Governmental agencies must begin to evaluate new technologies, indicating criteria for acceptance in hazardous waste management programs. Executives of some waste service companies recently reported to the U.S. Congress that delays by the U.S. Environmental Protection Agency in evaluating new technologies are major factors in failures to implement them on a commercial scale. (Anonymous, 1985d)

CONCLUSION

If the industrial sector of North America is to implement the public goal for better, more protective waste management, a renewed commitment by government and the public is needed for rapid development of these new technologies. The waste service industry is eager to invest in expansion of current capacities and development of new facilities. To accomplish these goals, however, federal and state officials, the public, and industry must be dedicated to reducing the current constraints on commercial development.

Siting problems must be resolved; regulatory standards identified and equally enforced, and permits processed expeditiously. We do not have the luxury of waiting several years to develop appropriate institutional mechanisms to address these problems. If we are to implement new treatment strategies to the fullest extent possible, it is necessary to commit sufficient public and private resources for expeditious development.

It is obvious that the tools for better management of hazardous waste are available. Greater protection to public health and the environment is possible. It is time for government officials, the public and industry work in a cooperative spirit to bring about full implementation of these tools.

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FAST-TRACK RESOURCE RECOVERY PROCUREMENT
BERGEN COUNTY, NEW JERSEY
A CASE HISTORY

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INTRODUCTION

Bergen County, New Jersey, with a population of approximately 850,000, is a highly urbanized area located directly across the Hudson River from New York City. Bergen County's solid waste disposal problems are acute as the County is totally dependent upon a single landfill which is now under State mandate to close within five years. The possibility of siting a new landfill, or of using an adjacent county's landfill, is essentially nil.

Facing this situation, the County, acting through the Bergen County Utilities Authority and its consulting engineer, Malcolm Pirnie, Inc., elected to develop a mass-burn, water-wall, refuse-to-electric power facility. It is believed that, at 2,720 metric tons (3,000 tons) per day, this facility will be equal to the largest in the world.

The Authority chose to implement this project through what is called the "full-service" approach, in which a private sector vendor is chosen to design, build and operate the facility for 20 years. The firm of American REF-FUEL was ultimately selected and is now under contract, at $253.3 million (US) to implement the project.

This paper will examine the history, methodology, schedule, and results of this project, which is perhaps the largest example to date of joint public sector/private sector partnership in the public works field. Key issues which will be addressed include:

- Procurement Approach
- Technology
- Environmental Impacts
- Financial Plan
- Risk Allocation
- Timing and Schedule
- Project Management

BACKGROUND

Bergen County is located in the northeast corner of New Jersey, and borders on Hudson, Passaic, and Essex Counties in New Jersey, Rockland County in New York and the Hudson River (Figure 1). Because its growing population of 850,000 was generating approximately 2,450 metric tons (2,700 tons) of waste each day, it became clear that, like so many other communities, Bergen County was in need of a long term solid waste disposal system that would be both economically viable and environmentally acceptable.

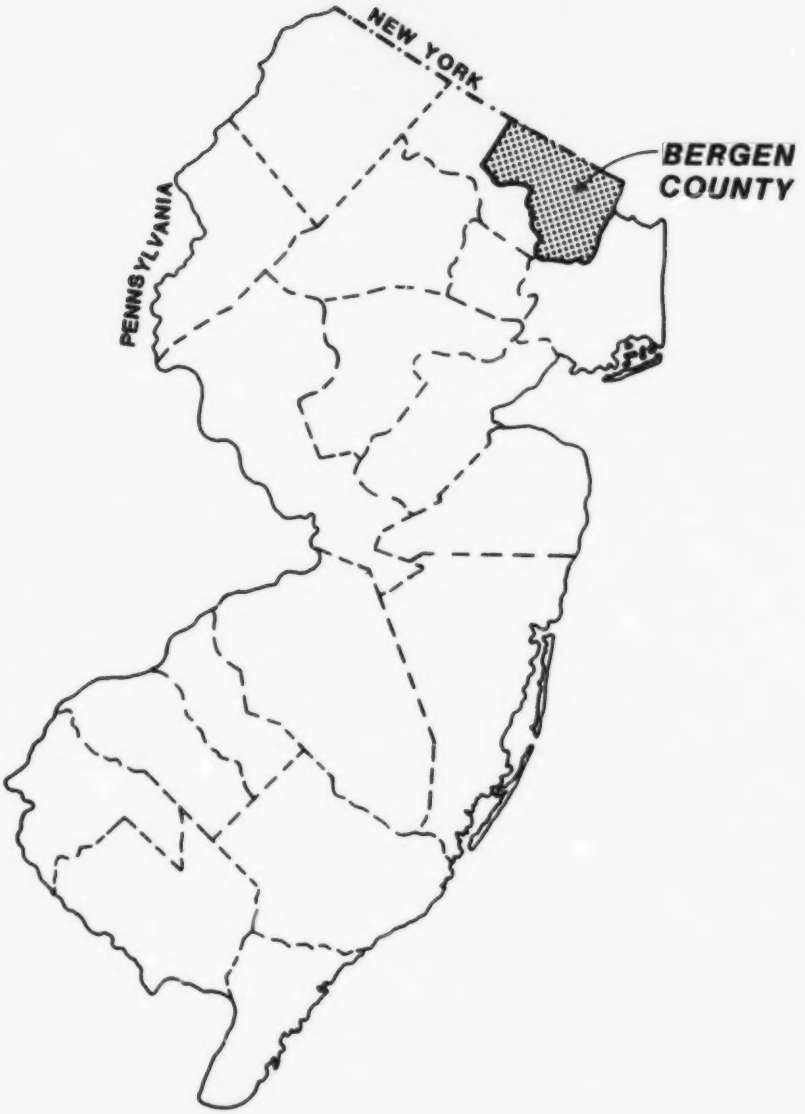

FIGURE 1

BERGEN COUNTY

At present, the County relies on the Kingsland Park Landfill in Hackensack Meadowlands, which currently receives approximately 3,450 metric tons (3,800 tons) of waste per day. The landfill, however, is expected to reach capacity in late 1987 at the current rate of waste disposal. For this reason, the Bergen County Utilities Authority (the Authority), charged with providing sewerage and solid waste disposal services in the County, developed a long term solid waste disposal plan which includes the development of a waste-to-energy resource recovery facility.

In 1984, a major change in U.S. tax law occurred, which required a substantial acceleration of the project schedule. This change, the Deficit Reduction Act of 1984 (DEFRA), placed a limit on industrial development bond (IDB) financing, as well as reducing or eliminating other attractive financial options.

As a result of these changes, which would reduce the tax advantages associated with IDB financing, the Authority decided to "fast-track" the project. This meant that all prefinancing activities had to be completed before the end of 1984, or six months from site selection and the decision to fast-track the project.

In short, Bergen County had to, and was able to accomplish in a six-month period what typically takes years to complete. The milestones achieved (Figure 2) included site evaluation, vendor selection and procurement, environmental impact statement preparation, approval and bond issuance. By conducting these activities simultaneously, the project team completed financing prior to the end of 1984, thereby avoiding the restrictions and additional project costs associated with DEFRA. The following discussion describes the activities which led to this successful project approach for the Bergen County Resource Recovery Program.

SITE SELECTION

One of the most difficult steps in any solid waste project is the selection and eventual justification to the public of a site for the facility. In Bergen County, this process has required years of evaluation, negotiation, public hearings, and even litigation.

This process is particularly difficult in an area such as northern New Jersey, which is highly urbanized and offers few open areas suitable for large-scale industrial type facilities. Over all, more than 50 sites were considered and evaluated in terms of such factors as:

- Zoning and adjacent land use
- Access
- Traffic impact
- Air quality impact
- Availability and cost
- Area

Ultimately, in June 1984 a site in Ridgefield, New Jersey was selected. Figures 3 and 4 show the site and its location in Bergen County.

TECHNOLOGY

A number of different solid waste disposal technologies were considered for Bergen County including continued landfilling, preparation and combustion of

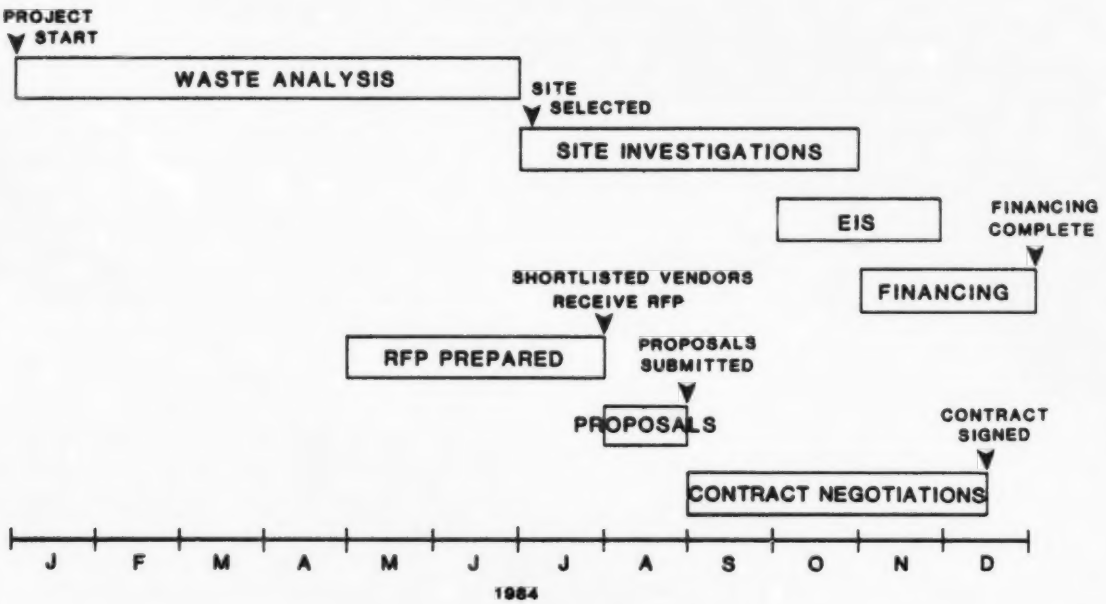

FIGURE 2

MILESTONES

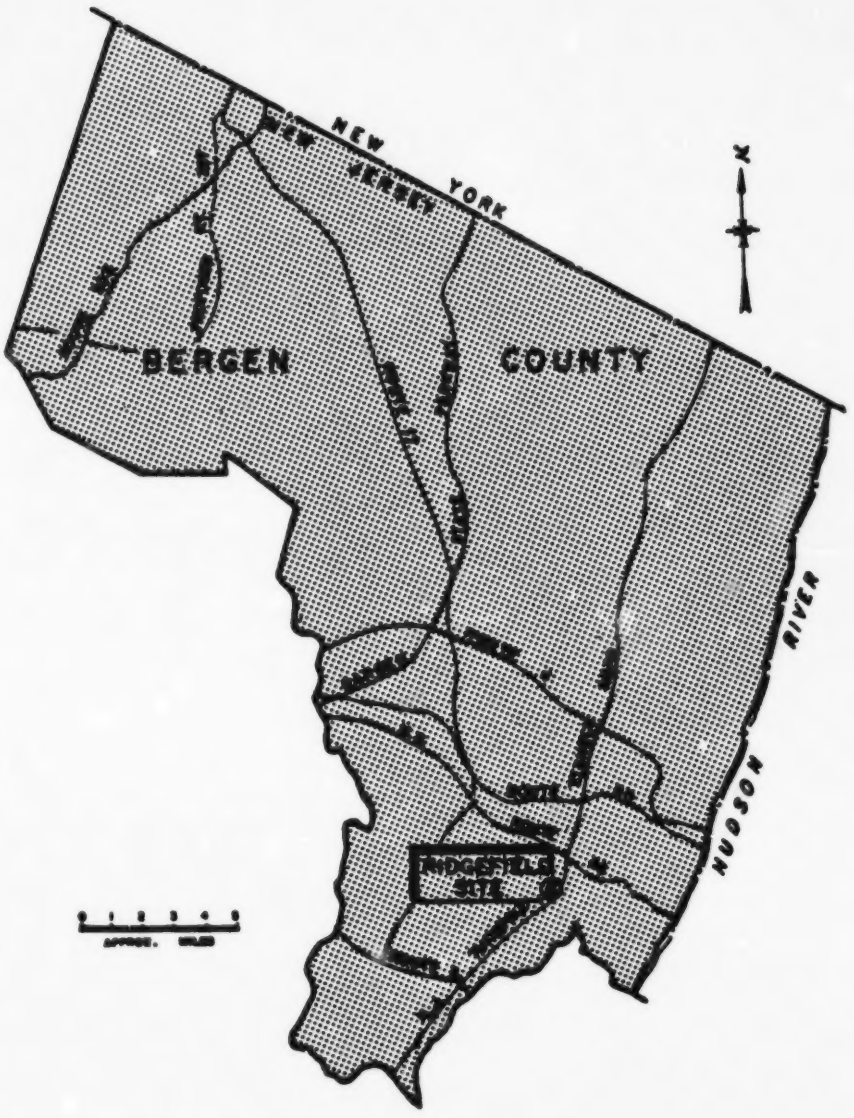

FIGURE 3

PROJECT SITE

FIGURE 4

PROJECT SITE

refuse-derived fuel (RDF), mass burn, and others, and these studies led to the conclusion that mass burn waste-to-energy technology was the most appropriate. The operating history, reliability, and environmentally sound operation of mass burn systems led to this affirmation.

In a typical mass burn system, as shown in Figure 5, waste is delivered to the facility (with no preprocessing) and dumped into a storage pit. The waste is fed by crane from the pit to a refuse hopper adjacent to the pit. The crane operator also has the capability to mix the refuse to provide a homogeneous fuel, and to remove items which because of size or composition would not be processable. Once the refuse enters the hopper, it falls by gravity into the combustion chamber where a grate system agitates the refuse and mixes it with sufficient oxygen to ensure full combustion.

A major advantage of the mass burn technology is that the ash generated represents an efficient burnout of waste, a volume reduction of about 90 percent, and is basically non-putrescible and non-combustible. Risk to human health and environmental degradation at the disposal landfill are, therefore, minimized.

In the selected waterwall mass burn system, the combustion chamber is lined with water-filled tubes, in which the combustion heat is transferred and steam is produced. In Bergen County's case, the steam will be utilized to generate electricity for internal plant use and for sale to the local public utility. Revenue from the sale of electricity will be used to offset project costs.

After heat recovery, combustion gases will flow through a dry scrubber/cyclonic separator and an electrostatic precipitator. This pollution control equipment will reduce particulate matter and acid gases to provide compliance with local, state and federal regulations prior to venting through the stack.

ENVIRONMENTAL ASSESSMENT

Reasonable assurance that environmental permits and approvals would be ultimately issued is legally required by federal and state regulatory agencies prior to financing. A preliminary environmental impact statement (PEIS) was prepared and submitted to the Commissioner of the New Jersey Department of Environmental Protection (DEP) to satisfy this requirement. In producing the PEIS, a thorough site investigation was prepared, including: general site description, hydrogeological assessment, air pollution model and projection, and a wetlands mitigation plan. The PEIS was completed in approximately six weeks, and approved by the DEP in November, 1984. The PEIS, with additional material, also served to satisfy the federal requirement.

PROJECT IMPLEMENTATION

Bergen County's choice of methodology for implementing the resource recovery program must be understood in the context of available choices. There are three basic ways that public works projects are implemented, and two ownership options. These are:

- Conventional public works/public ownership
- Turnkey/public ownership
- Full service/public ownership
- Full service/private ownership

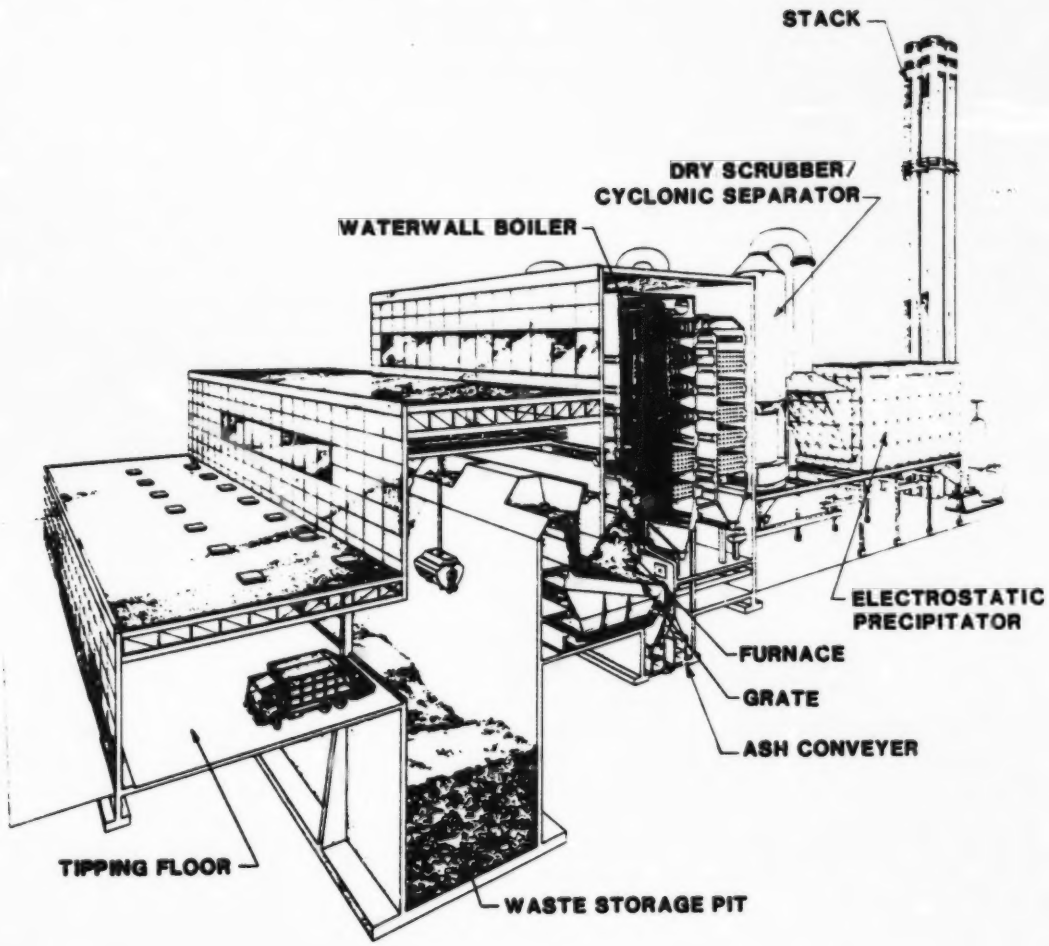

FIGURE 5

BERGEN COUNTY UTILITIES AUTHORITY RESOURCE RECOVERY FACILITY, BERGEN COUNTY, NJ

Table 1 presents an overview of the roles and responsibilities of the various parties under different implementation/ownership approaches.

CONVENTIONAL PUBLIC WORKS

This is the traditional approach to public works projects in the United States and still the method by which the overwhelming majority of such projects are done. In this approach, the governmental entity involved (city, county, agency, authority or other) engages an architect/engineer to design the facility and prepare bid documents (plans and specifications) which are then the basis for formal competitive bids. The construction contract is awarded to the low bidder, who then constructs the facility, with the construction administered by a representative of the governmental agency. The facility is owned by the government and responsibility for operation also rests with the government, which operates the facility either with its own forces or by contract with a private operator.

The advantage of this method is that it gives the governmental entity the greatest degree of control over the project. This may be significant if the community wishes to have more than the regulatorily mandated degree of environmental protection or wishes to invest extra resources in redundancy or facility aesthetics. There is also the potential for cost savings with this method because of the competitive low bid approach, and because of the elimination of the profit margin/risk premium charged by a full service vendor. On the other hand, these cost savings may be negated by lost tax benefits available to privately owned facilities, as well as by inefficient public works procurement approaches required in certain jurisdictions.

The major drawback of this method, however, is the degree of risk which the governmental entity is required to take. The main reason for this is the lack of single-point responsibility: in the event of a failure it may be difficult to pinpoint the responsibility and costly litigation may result. In addition, certain proprietary processing systems are not available under this approach, as their owners prefer to market these systems as part of a full-service package.

TURNKEY

In this approach the responsibilities for design, construction and startup are assigned to one entity, the vendor (or full-service contractor). This reduces the risk to the governmental entity substantially, since if the facility does not meet performance specifications it need not be accepted. In addition, design and construction cost overruns are borne by the vendor.

However, the government does own and operate and facility, and the risks of long-term operation and marketing arrangements are still its responsibility.

FULL SERVICE/PUBLIC OWNERSHIP

In this approach, a full-service contractor designs, constructs, provides start-up and operates the facility, which is, however, owned by the government. This approach has several advantages:

- Greatest degree of risk avoidance for the government
- Single-point responsibility for performance and cost

TABLE 1

RESOURCE RECOVERY PROCUREMENT
IMPLEMENTATION RESPONSIBILITIES

Implementation Methodology	Project Element: Design	Construct	Supervise Construct	Startup	Operate	Own	Procurement Method	Example
Conventional Public Works	A/E	C	C/M	C & A/E	G	G	A/E Design Low Bid Construct	Glen Cove, NY
Turnkey	V	V	V	V	G	G	RFQ/RFP	
Full Service	V	V	V	V	V	G	RFQ/RFP	Pinellas County, FL
Full Service w/Private Ownership	V	V	V	V	V	V	RFQ/RFP	Westchester County, NY

G Indicates Activities under Governmental Responsibility

V Indicates Activities under Vendor Responsibility

A/E Architect/Engineer
C Contractor
C/M Construction Manager
G Government

Activities under vendor responsibility may be done by vendor forces or may be subcontracted at vendor option.

At the same time there are also disadvantages:

- Loss of control and flexibility
- Potential for higher cost due to risk premium and vendor profit margin

FULL SERVICE WITH PRIVATE OWNERSHIP

This option is very similar to full-service with public ownership in that again the vendor designs, constructs and operates the facility. However, in this case the vendor has the added role of owning the facility. The primary advantage of private ownership is the capture of various tax benefits (depreciation and investment tax credits) available to the private sector but lost with public ownership. The primary disadvantage is loss of ownership, which means that at the end of the service agreement (usually 20 to 25 years) the facility belongs to the private vendor even though it has been paid for with fees collected from the public.

SELECTION OF IMPLEMENTATION METHODOLOGY

Because of the scale and complexity of the Bergen County project, and because of the desire to reduce early-year costs through the capture of tax benefits, a full-service with private ownership approach was taken.

PROCUREMENT APPROACH

Broadly speaking, public works projects in the United States can be procured in three ways:

- Competitive bids
- Request for Qualifications/Request for Proposal process
- Sole source negotiations

The competitive bidding procedure, although very common for public works projects, was not applicable for Bergen County, as it is not consistent with a full-service implementation. This is because the competitive bid approach requires detailed plans and specifications. In the full-service approach these are prepared by the vendor <u>after</u> selection, and are, therefore, obviously not available to solicit bids.

The sole source negotiation approach is a non-competitive approach, only suitable when only one vendor can supply a product or service.

The approach used in Bergen County, and the approach appropriate for a full-service project, is the RFQ/RFP process.

Two general variations of this approach are used:

- Traditional RFQ/RFP
- RFQ/RFP with competitive negotiations

Figure 6 illustrates the essential difference between these approaches. In a traditional RFP approach, multiple priced proposals are solicited from short-listed vendors, evaluated and a top-ranked vendor chosen <u>before</u> the service agreement is negotiated. In theory, if a satisfactory service agreement cannot be negotiated with the first vendor, one then terminates negotiations and

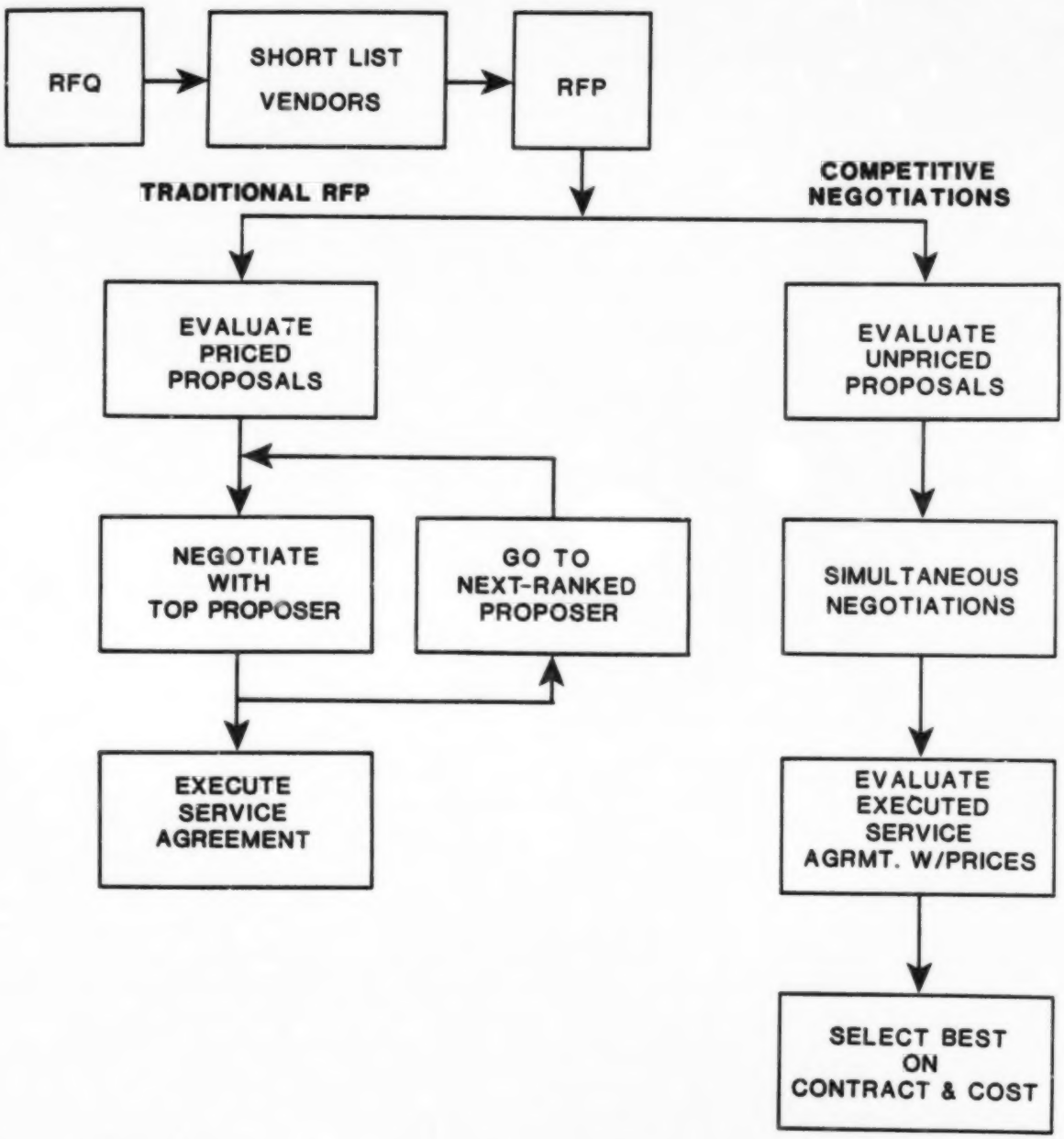

FIGURE 6

COMPARISON OF PROCUREMENT APPROACHES

moves on the next lower ranked vendor. In practice, once several months have been invested in contract negotiations with one vendor, it is very difficult for any governmental entity to abandon that effort and start over. The vendors have been very skillful at exploiting that reluctance to their own advantage.

The competitive negotiation approach, which was used in Bergen County, avoids that problem by simultaneously negotiating service agreements with several (in Bergen County, three) vendors. Executed agreements and final prices are then submitted by all vendors at once. By keeping the competition alive until the end of the process, both a quicker resolution and a better deal can be obtained.

VENDOR EVALUATION AND PROCUREMENT

For Bergen County, this process began with the prequalification of four vendors:

- Signal RESCO
- American Ref-Fuel
- Ogden-Martin
- Blount

Each of these vendors is the U.S. licensee of an experienced European designer/builder of mass-burn refuse-to-energy systems, and each was believed to be financially qualified to undertake the project.

Following the shortlisting of prequalified mass-burn waste-to-energy vendors (Signal RESCO, Ogden-Martin, American Ref-Fuel and Blount), the final vendor selection process was initiated after site selection in June, 1984. A Request for Proposals (RFP) was issued to the prequalified vendors at the beginning of August, 1984, and proposals were received at the end of August. Blount chose not to submit a proposal. This left only four months for the evaluation of proposals, vendor selection and the successful completion of contract negotiations.

The RFP provided the vendors with project information and required them to meet the following minimum contractual positions, among others:

- 25 percent contractor equity contribution
- Contractor acceptance risk of tax law change
- Recourse to parent corporation contractor on performance guarantees
- In the event of contract termination due to contractor default, contractor responsibility for project bonds
- U.S. $11 per metric ton ($10 per ton) maximum increase in service fee due to uncontrollable circumstances

Because of the brief time period available, the Authority decided to evaluate and select vendors through a process known as competitive negotiation. As shown in Figure 7, contract negotiations with each vendor occurred essentially simultaneously, resulting in the development of three separate contract agreements. As information became available from the detailed site investigations (borings, property surveys, utility surveys), it was transmitted to the vendors to enable them to finalize their cost proposals.

Meeting project deadlines meant that the vendor selection team, consisting of representatives from the Authority, engineering consultants and legal and

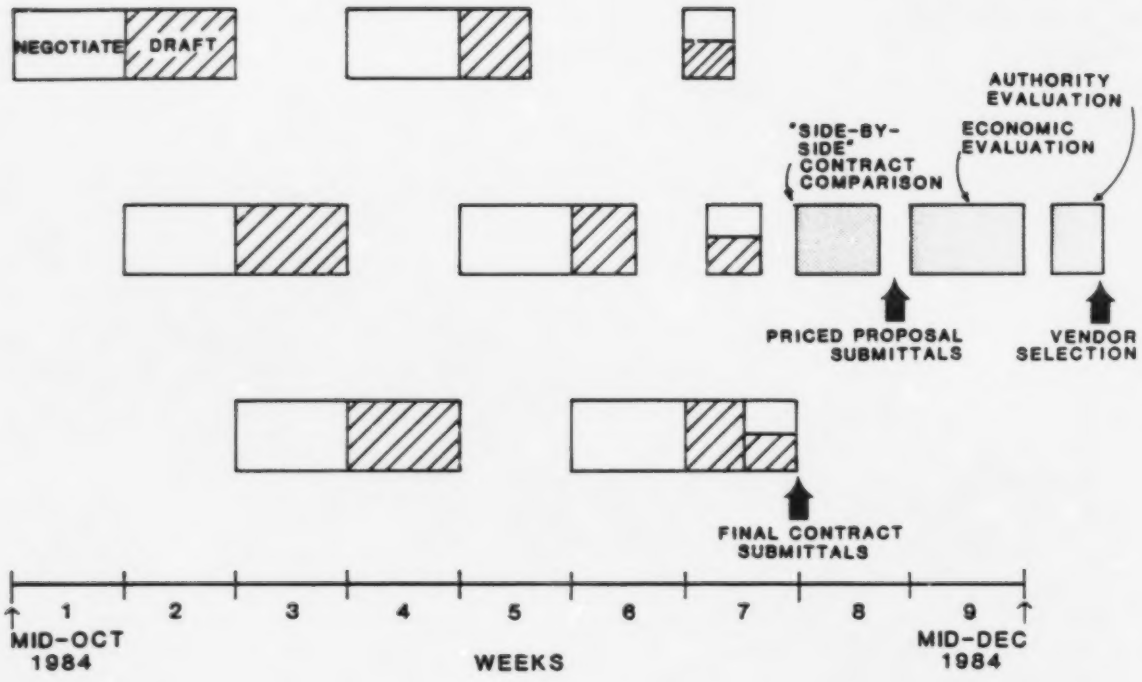

FIGURE 7

VENDOR NEGOTIATION

financial counsel, were involved in a concentrated negotiating process. This meant 12-hour days, 6-day weeks, and very quick decision response times from the Authority Board on key issues that arose during the negotiation process.

Negotiations with each vendor centered around the following key issues:

- Risk allocation
- Facility specifications
- Waste stream characteristics and guarantees
- Facility downtime considerations
- Acceptance and disposal of hazardous waste
- Unforeseen circumstances and their consequences
- Acceptance testing
- Performance guarantees
- Contract termination rights by parties

In order to evaluate the final contract agreements as objectively as possible, the difference between the vendors in risk allocation were identified during the negotiations. For evaluation purposes, a dollar figure was estimated for contractual provisions involving a financial risk to the County. These figures were then used to adjust the net present value resulting from the final cost proposals submitted by vendors to comparatively evaluate their contract agreements. The vendors were notified of the proposed dollar evaluation penalties for various contractual positions prior to their submittal of final agreements and costs. This way, each vendor was aware of the "value" of each unsatisfactory element of its proposed contract before the final contract was submitted with its associated cost information.

The following elements related to cost were required in each vendor's cost proposal:

- A proposed service fee structured as follows:

  $$SF = DS + OM + PT - RRC$$

  where
  - SF = service fee
  - DS = debt service based upon vendor's capital cost bid
  - OM = operations and maintenance cost as bid by the vendor for first year and subject to annual CPI escalation
  - PT = pass-through costs, as identified by the Authority
  - RRC = resource recovery credit from the sale of electricity (the vendors proposed a percentage share for the Authority and the electric purchase rate was developed by the public utility)

- A 25% vendor equity contribution.
- A 1,815 metric ton (2,000 ton) per day put-or-pay commitment from the Authority.

Once the final contract agreements were received, the project team proceeded with their evaluation based on a present worth economic analysis and certain previously identified assumptions regarding annual escalation rates, waste characteristics, electric purchase rates, etc.

Some of the significant contractual differences among competing vendors are listed in Table 2. As mentioned above, in cases where a vendor took a stance on

TABLE 2

SIGNIFICANT CONTRACT DIFFERENCES

ISSUE	VENDOR 1	VENDOR 2	VENDOR 3
Facility Testing	Continuous Monitoring	Challenge Testing	Challenge Testing
Company's Termination Rights	Fair Market Value or Outstanding Bonds Company Remains Owner	1. Outstanding Bonds - Company Remains Owner 2. Authority Purchase Facility for - Outstanding Bonds - Outstanding Bonds plus Equity & Tax Schedules - Fair Market Value	Fair Market Value or Outstanding Bonds Company Remains Owner
Additional Service	Above 795,000 MTPY (876,000 TPY): U.S. $20.67/MT (U.S. $18.75/ton) Escalated	663,000 to 795,000 MTPY (730,000 to 876,000 TPY): U.S. $14.76/MT (U.S. $13.39/ton Escalated Above 795,000 MTPY (876,000 TPY): Lower of U.S. $13.39/ton or Market Price Escalated	Above 795,000 MTPY (876,000 TPY): Market Price

a contractual position which placed the County in financial or other risk, compensatory dollar adjustments were made in the evaluation of the vendor's bid.

After evaluation adjustments were made to the vendor's original bid to reflect County financial risk, annual costs and revenues were reduced to a "present worth" figure. A summary of the vendor bids is given in Table 3.

Selecting a vendor at this point was a matter of determining the one with the associated lowest present worth cost whose proposed contract did not contain provisions which would violate the basic project needs. On this basis, American Ref-Fuel was selected. Figure 8 is an artist's rendering of the resource recovery facility which they are proposing.

SUMMARY

The result of this negotiation approach was the selection by December 15, 1984 of a vendor with a final contract acceptable to both parties and ready for signature without further negotiation. The success of the process can be measured by the additional millions of dollars which the County may have been required to spend if financing occurred after 1984. Less quantifiable but equally significant is the fact that the rapid completion of several major project milestones allowed the County to move forward with its solid waste management plan and the provision of sound solid waste disposal for the County's residents.

TABLE 3

SUMMARY OF BIDS

	VENDOR 1	VENDOR 2	VENDOR 3
Facility Capacity at 11.5 J/Kg (at 5,500 Btu/lb) waste	2,720 MTPD (3,000 TPD)	2,600 MTPD (2,880 TPD)	2,340 MTPD (2,580 TPD)
Facility Price (U.S. $ Million)	$ 253.2	264.5	391.2
O&M (U.S. $ Million)	11.6	12.9	27.6
Additional Waste Fee $(U.S.)/MT $(U.S.)/ton	0 0	14.76 13.39 Escalated	0 0
Energy Guarantee (kwh/MT) at 11.5 J/Kg	692	723	711
(kwh/ton) at 5,500 Btu/lb. of waste	(628)	(656)	(645)
(kwh/MT) at 9.4 J/Kg	531	496	584
(kwh/ton) at 4,500 Btu/lb. of waste	(482)	(450)	(530)
Energy Share	75 → 90%	90%	90%

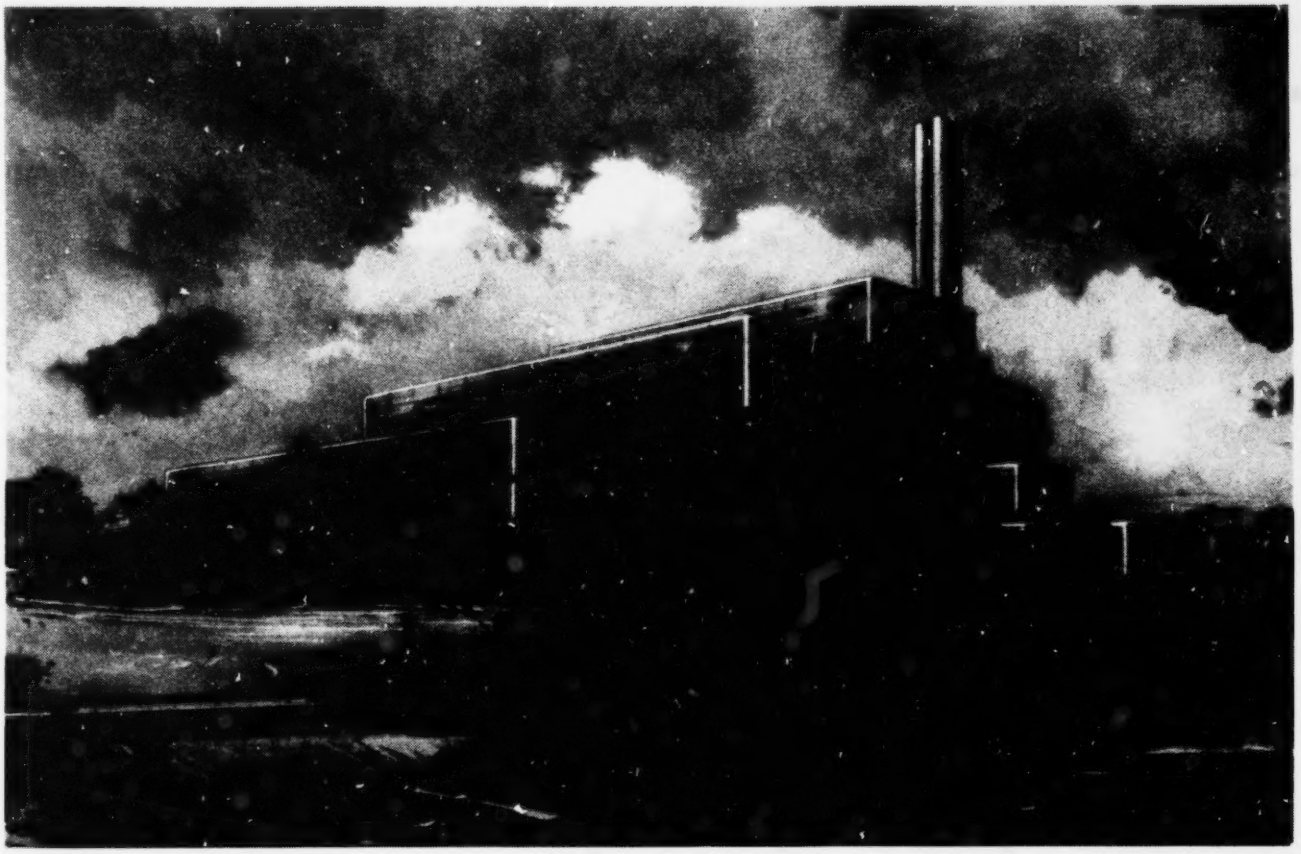

FIGURE 8

ARTISTS RENDERING OF PROPOSED AMERICAN REF-FUEL FACILITY, BERGEN COUNTY, NJ

LEGAL ISSUES

Barbara D. Little

Jackson, Kelly, Holt and O'Farell

Paper unavailable at time of printing

CRISIS IN CONFIDENCE

Michael Keating

Environment Reporter

The Globe and Mail

You have all seen the headlines:

- PCB poisons build up in the body.

- City could become PCB dump, mayor asserts.

- Toxic wastes: tip of the iceberg.

- Town fights plan for toxic waste treatment plant.

- Industries cited for dumping hazardous wastes.

- Lack of planning for disposal crisis may lead to shut-downs in industry.

These are just a few headlines culled from my files on waste management.

They come not from what is called the sensational press but from such journals as The Globe and Mail, including the Report on Business section, The New York Times and New Scientist magazine of Great Britain.

Let me take key words from those headlines and assemble a headline of my own. It says the news media sees a crisis in confidence over government and industry's handling of toxic wastes.

When Nancy Cluff invited me to speak she asked me to deal with such issues as:

- How do the news media deal with waste management?

- What do reporters look for?

- And how should you people respond to our questions?

Well, are the media accurately reporting the facts?

Are we fair? Are we manipulated by different interests? Are we biased against new waste treatment sites? Are we whipping up public opinion against such sites?

My answers are: usually, sometimes, yes, no and maybe.

If I were smart I would stop right now. But I rashly promised to try to give some explanations about how we work, so here goes.

I am assuming that most of you have relatively little knowledge of how the news media operate so I'm going to spend a little time explaining some basic mechanics of news organizations and news judgment. I'll leave you to draw your own conclusions about whether or not we are doing a good or even adequate job.

For starters the news media are not a monolith any more than the worlds of politics or business are monolithic and homogeneous.

The media are basically a group of businesses with a more or less common theme of providing information, including news, commentary and advertising, though often in very different styles.

I will deal particularly with newspapers but much of what I say is paralleled in some form by magazines, radio and television.

Who does what inside a newspaper?

The news story is typically written by a reporter, is filed with a copy editor, who reads it for style, grammar, writes the headline and may cut the story to fit a limited amount of space assigned to it on a given page. Stories may come from staff reporters, freelance writers who cover regions where we lack staff and from the news services, which transmit stories from their own reporters or from other news media around the world in a giant news pooling operation.

In the paper there is chain of command which judges which stories will be assigned and which used. This chain includes a series of copy, assignment, page, section, metro, national, foreign, assistant managing and managing editors.

The internal structure in a large paper includes a series of departments including news, features, business, etc., often operating semi-independently in terms of what stories they assign. For example you might have a news reporter working on an environment story on the basis of who said what today and a feature writer composing a piece pulling together the history of the issue.

In addition you can have an editorial writer drafting an opinion piece which gives the editor's opinion about what should be done about the situation.

The editor is at the top of the news hierarchy although that person is rarely involved in the day to day selection of most news stories unless there is a question of a change of policy or a legal issue such as libel.

The publisher is the "president" of the paper, setting overall policy for its management and operation but usually leaving the news content to the editor or editor-in-chief as the title may be.

What about the content?

We have been called an imperfect mirror of the world.

We have been accused of sensationalism, fear-mongering, scare headlines, misquotes, inaccurate or incomplete stories.

How do we choose what we call news?

Vast amounts of material, tens of thousands of words a day, flow into the offices of a large newspaper so we are highly selective in what we choose to print.

It is not a precise science. For example a story which would get good coverage one day will get bumped to the back pages on another day because of other major, breaking news events such as an air crash, assassination or collapse of a government.

The problem is that there is just so much space in the paper each day and every time one story is chosen another one gets bumped.

How do the news media approach issues?

The media often cast themselves in the role of an unofficial opposition critic to governments and there is something of a tradition of standing up for the underdog in conflicts.

And yes our pages are full of conflicts which is not suprising given that our historical role has been to challenge ideas with other ideas and to act as a forum for different viewpoints.

It is not usually the role of journalism to settle an argument. That is done by the parties who we quote. The media act as a marketplace for opinions.

That is why traditional journalistic thinking holds that it is better to read many stories about a given issue and, if possible, read different journals to garner as wide a range of opinions as possible.

Redress: an issue on the mind of anyone who thinks they have been wronged by the media.

If you are unhappy with what was written, or if you want to comment on an article, to challenge it, or simply elaborate on it, call the editor or write a letter to the editor. Most papers have a policy or printing corrections.

If you have the expertise in a given subject which is in the news and are can write clearly and concisely then you can propose writing an article yourself. Most papers have an opinion page for guest writers, Page 7 in the case of The Globe.

Let's deal with news as it affects you and particularly with the relatively new field of environment reporting-- a specialty which is just coming of age.

There a change in attitude toward environment issues on the part of the media similar to the one taking place in government and industry.

Until recently there has been a peculiar schizophrenia in the approach of people toward the rest of the environment, our biosphere. On one hand it was taken for granted as something unchanging and relatively unaffected by our actions. Whenever the state of the environment was thrown into question is was treated as a passing crisis which could be patched up.

Now the environment is starting to be treated as a permanent, major issue by our bureaucracies. In the case of the news media this means that environment is finally being treated as a specialty to be covered systematically like the more traditional fields of coverage such as politics, courts, police, business, sports, fashion and labor.

It is unfortunate, however, that there are still so few environment reporters. The public debates suffer from uninformed coverage by writers who are trying hard but lack the technical understanding and the historical background about the issues.

Environment reporting is one of the most complex areas to work in. I would wager that the issues are among the most difficult we must decipher and rank in complexity with astrophysics and the search for subatomic particles.

There are so few givens. We understand so little of how our environment works and what we are doing to it.

It is a field laced with uncertainties and half-truths, where it is easy to mislead without even trying. For example people often fail to mention that a certain toxin was not found because of a high detection limit in the search procedure. They rarely point out that the toxin may well have been there but at a lower level.

Let me deal with some of the issues which we both must wrestle with in the days ahead.

For example why people fear waste disposal.

Well, the answers are pretty obvious. They include, toxins in drinking water and poisoned wells, leaking dumps-- the Love Canal syndrome-- criminal activity in the waste management field and particularly a long series of government and business decisions which do not seem to be protecting the environment.

What can you expect from the news media over such touchy and topical issues as:

- The Ontario Waste Management Corporation zeroing in on a site for its hazardous waste treatment centre.

- Proposals for the mobile destruction of PCBs.

- The Transportation of Dangerous Goods Act.

- Incineration, particularly energy from waste.

- Coping with old landfills.

- New technologies for treating hazardous waste.

- Recycling.

Well you can expect plenty of questions. And so far you are not even able to answer such fundamental ones as:

- How much waste is there in Canada?

- How hazardous is it?

- How many abandoned dumps are there?

- What is happening to the chemicals in dumps now?

Who do we in the news media listen to?

Well, we do look to government and industry for most of the basic answers. After all those are the people who create, regulate and finally try to control toxic wastes.

Ironically it is often the government agency that gave us the information which later accuses the press of sensationalism.

This is simply a reflection of the bind that environment departments find themselves in whenever they tackle a complex issue like a leaking dump.

For example governments have created powerful research laboratories capable of detecting toxic chemicals as well as anyone in the country.

The minister proudly announces the purchase of a $500,000 gas chromatograph - mass spectrometer one day. But soon afterward that same minister is presented with the news that the beautiful machine has found dioxin in the fish, PBCs in the mud, trihalomethanes in the drinking water and furans in the air.

The politician, who likely never even heard of a GCMS before taking the portfolio, and who probably has even less knowledge of risk assessment, calls in the advisors. What the hell does it all mean?

If the advisors follow the traditional line of thinking they will say that the amounts of chemicals are small so there is no sign of immediate risk.

They may or may not explain that that the chemical analyses are only roughly accurate and that the risk assessments are based on tests made on laboratory animals and give only vague guidelines as to the long-term health effects on a diverse human population.

All too often the minister stands up in the house and says: we have just found the most deadly synthetic chemical in the world but don't worry. It won't hurt you. We have the safest water in the world.

Well, who else do we listen to?

We also listen to anyone who appears to have something worthwhile to say about an issue. Certain outside commentators have established some credentials-- in particular a number of environment groups, some of which have considerable expertise. They may not be able to provide all the answers but they often know which questions should be asked.

We listen to university teachers who have or appear to have expertise on subjects.

And we listen to people who are directly affected.

The farmer living beside the waste treatment site may not be an expert on toxic chemicals but he may know a lot about the state of the ground and local flooding patterns.

We listen to local interest groups.

I have seen a housewife with a phone and a standard reference book on chemicals do a far more effective job communicating information about a proposed chemical treatment plant than a whole government information department, which did not seem to be sure what message it was supposed to convey.

The recent conflicts over who is right and wrong have created a sense of mistrust.

To illustrate the point I recall a symposium on risk assessment about three years ago. A provincial environment official told the meeting that whenever his ministry announced that it had found a problem people believed him. But when they issued a statement that something was safe people did not believe him.

Until government and industry you can give us the public some clearer answers of course there is going to be suspicion and that is only normal.

The best way to change that perspective is to provide the country with some concrete changes. You will be judged by the media and public by your actions more than your words.

You face a rocky road ahead until you get an acceptable treatment plant up and running. The history of waste management is littered with cases of expediency just plain carelessness and outright criminality.

People are suspicious with good reason. You are not going to regain public confidence until you treat the handling of poisons in our wastes with the same care that people do when it comes to hazards in our foods. You only have to look at the tuna scandal to realize that the public will not look kindly on anyone who is not doing their best to protect public health.

When it comes to the tough decision of putting waste treatment in somebody's backyard you are going to have to give displaced people at and near the new disposal plants rather generous compensation. After all they are the ones who must carry the can for our society's inability to stop creating wastes in the first place.

How should you deal with the news media when it comes to waste management?

My first advice is to be candid about the problems and the risks. And that is not just for my benefit. Oh, sure you can get away with misleading and incomplete statements for quite a while if you want to. But they have a nasty way of catching up with you and the penalty is the lack of confidence by the public and the press which makes it very difficult for you to accomplish anything good.

If is there is the slightest suggestion of opportunism-- that sites or techniques are being selected for anything but their suitability for waste disposal-- then you will see a massive wall of resistance and a further erosion of public confidence.

If there is one final thought I can leave with you it is this. We all live in a highly technical society but people in waste management even moreso than most.

It is easy to become enamored of a certain technique or to become immersed in huge amounts of data. In most stories I find that I am overwhelmed with large amounts of data but precious little hard analysis which tells me what it really means to my well-being.

And that is my point ladies and gentlemen. Don't ever forget that no matter what the title on your desk says you are also in the public health protection business and your decisions better reflect it.

Thank you for having me here today.

* * *

UPDATE ON POLLUTION INSURANCE AND TRENDS IN ENVIRONMENTAL RISK MANAGEMENT

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The ability to transfer potential environmental liabilities through insurance has diminished markedly in the last 12 months. Most Comprehensive General Liability policies issued today contain full exclusions for pollution liability. At the same time, the market for pollution insurance has constricted greatly. This paper discusses the recent trends in insurance coverage for pollution liability. It also considers some alternatives to insurance that corporations are exploring. A clear trend to emerge is the increased emphasis on environmental risk management within corporations.

COMPREHENSIVE GENERAL LIABILITY POLICY

Before the 1970's, coverage for pollution damages was provided by a Comprehensive General Liability (CGL) insurance policy, which covers numerous liability risks. During the early 1970's, CGL policy wording was changed to exclude coverage for all pollution that is not "sudden and accidental." That is, the intent was to exclude all claims arising out of gradual pollution. However, most CGL policies issued today exclude all pollution liability. The distinction between sudden and non-sudden pollution is generally not used today. In fact, the new CGL form drafted by the Insurance Services Office for use beginning in 1986 excludes all pollution, except for products and completed operations. Thus, corporations are faced with absolute pollution exclusions in their CGL policies, if not already, most certainly by next year.

Broad court interpretations of CGL policies with respect to pollution were a major contributor to the insurance industry's decision to impose an absolute exclusion for pollution. While coverage rulings have varied, a number of courts have interpreted the meaning of "occurrence" in the CGL quite broadly, finding pollution coverage for companies whose pollution damage was neither "expected nor intended." That is, damage that was neither expected nor intended was ruled to be an "occurrence", triggering coverage, regardless of the exclusion for gradual pollution. In other cases, the gradual pollution exclusion was ruled to be ambiguous and the coverage dispute was ruled in favor of the insured.

POLLUTION LIABILITY INSURANCE

The market for nonsudden pollution insurance (EIL) developed slowly. In 1973, a London-based EIL market was formed and in 1980, two U.S. insurers began offering EIL coverage. By mid-1981, five insurance companies were writing EIL coverage. By the end of 1982, four other markets had developed. One of these markets was the Pollution Liability Insurance Association (PLIA), a reinsurance pool that is now made up of approximately 40 member companies. In 1983, eleven major markets were writing coverage. In 1984, only nine major markets were writing EIL. Presently, only three pollution facilities exist: American International Group (National Union Fire Insurance Co.); Swett and Crawford (St. Paul Surplus Lines); and the Pollution Liability Insurance Association.

Not only has the number of companies offering EIL decreased, so have the limits of coverage available. Until 1983, the maximum policy available was $30 million per occurrence/$60 million annual aggregate. Today, maximum limits available are $10 million per occurrence/$10 million annual aggregate.

The dwindling capacity for EIL has resulted from a combination of several factors. An important factor has been the lack of reinsurance support, due in large part to the uncertainties inherent in this class of business. A related reason has been the judicial trend toward the broad interpretation of insurance contracts. Also, increasing uncertainty has developed over the impact of existing environmental laws. An underlying reason behind the restriction of pollution coverage is the cyclical nature of the insurance industry. The industry has just returned to a "hard market," where premiums are higher and capacity lower for most lines of business. Most insurance companies are achieving high premium writings without needing to venture into the presumed uncertainties of pollution. Moreover, the insurance industry has been faced recently with large net underwriting losses in the property and casualty market. This most certainly has added to the industry's aversion for pollution risks.

COVERAGE UNDER EIL POLICIES

EIL policies are intended to cover claims which the insured is legally obligated to pay for third-party bodily injury or property damage resulting from the unexpected, gradual discharge of materials from specifically designated locations. Most of the policies restrict coverage to the United States (its territories or possessions) and Canada. The policies provide a broad definition of gradual pollution conditions or environmental damage: discharge, dispersal, release, escape of smoke, vapors, soot, fumes, acids, alkalis, toxic chemicals, liquids or gases, waste materials or other irritants, contaminants or pollutants into or upon land, the atmosphere, or any watercourse of body of water. Some policies cover sudden as well as nonsudden pollution. Other policies cover only gradual pollution, although

it is often feasible to amend the policy (for additional premium) to include sudden pollution as well. The demand for sudden coverage in EIL policies has increased recently due to the elimination of sudden coverage in general liability policies.

All EIL policies are offered on a claims-made basis only. That is, the claim must be reported while the policy (or extended reporting period, if applicable) is in effect. An EIL policy is written for a 12 month period. Each policy is written with a limit for each pollution incident (occurrence) and a total limit for the policy year (annual aggregate). Some policies have a provision for a retroactive date; environmental impairment must occur in whole or in part subsequent to this date. Policies typically will not include coverage for: damages for liability incurred by non-insureds assumed under contract; injury to employees; willful or knowing violation of a law; damage to property owned, occupied, rented, used or in the control, care or custody of the insured; fines and penalties; and pre-existing pollution conditions. Wording of policies vary. It is important to read individual policies to determine specific coverages and exclusions.

THE NEED FOR EIL

In the United States, owners and operators of hazardous waste landfills, surface impoundments and land treatment facilities are required under the Resource Conservation and Recovery Act (RCRA) to show gradual pollution limits of $3 million per occurrence/$6 million annual aggregate (some state requirements vary). This can be shown through an EIL policy or by passing a financial test. A larger group, hazardous waste treaters, storers and disposers, must show sudden and accidental pollution coverage limits of $1 million/$2 million. Until recently, this coverage was usually shown through a Comprehensive General Liability (CGL) insurance policy (a financial test is also allowed). However, because most CGL policies exclude coverage for all pollution damage, corporations increasingly are purchasing EIL policies that cover both sudden and gradual pollution.

Because pollution coverage is not widely available, the U.S. Environmental Protection Agency is presently allowing "good faith" efforts to obtain insurance to be used by those that must certify coverage. "Good faith" is being evaluated on the basis of several criteria: submitting a completed application in a timely fashion; submitting evidence of attempts to acquire insurance; and submitting applications to "known" suppliers of EIL. On August 21, 1985, EPA opened a 30 day comment period on numerous aspects of the requirements for sudden and nonsudden pollution insurance. The comments will be used by EPA to evaluate whether revisions to the financial requirement are necessary in light of the current state of the insurance market. EPA requested comments on 5 possible regulatory approaches to the problem of limited insurance availability:

maintain the existing requirement; lower the required levels of coverage; authorize other financial responsibility mechanisms; authorize waivers; or suspend or withdraw the liability coverage requirements. Of particular concern to EPA and corporations is the November 8, 1985 deadline imposed by Congress in the 1984 amendments to RCRA. By this date, land disposal facilities must show evidence of financial responsibility (as well as groundwater monitoring) or they will automatically lose interim status.

Most of the purchasers of pollution insurance are not required to do so because of statute or regulation. Rather, they are interested in transferring certain liabilities through insurance. The demand for pollution coverage has never been stronger. Factors that have increased the demand include the heightened awareness of pollution liability, the restriction of the CGL policy regarding pollution and the imposition of more stringent environmental laws and enforcement.

COMMERCIAL ALTERNATIVES TO INSURANCE

As the availability of pollution insurance has decreased, corporations are exploring alternatives to commercial insurance coverage. These alternatives have included self-insurance programs, the formation of captives or pooling arrangements and an increased emphasis on environmental risk management.

Self-Insurance

Self insurance takes an wide variety of forms. The simplest self-insurance mechanism is the retention of risk by a company without funding for it. An obvious disadvantage for pollution liability is that losses are paid out of a company's working capital. Another way to self-insure is to create an internal reserve of funds that would be available to pay losses. Using either mechanism, it is essential that a corporation fully understand potential environmental liabilities so that the exposure can be managed adequately. As discussed later, this need has resulted in an increased reliance on principles of environmental risk management.

Captives

Another mechanism that can be considered is the formation of a captive insurance company, a subsidiary formed by a parent company for the purpose of writing all or some of the parent's loss exposures. "Association captives" are owned jointly by several parent companies, while a "pure captive" is owned by one company.

At least two hazardous waste trade associations in the United States are exploring the feasibility of forming association captives for pollution liability. A major hurtle they must deal with is the lack of reinsurance support.

ENVIRONMENTAL RISK MANAGEMENT

As the transfer of pollution liability through insurance becomes more difficult, corporations are recognizing that it is more important than ever to understand their potential pollution liabilities. Because companies are self-assuming much of their pollution exposures today, the incentive to identify, evaluate and reduce pollution liability has increased greatly. Corporations are turning to the relatively new field of environmental risk management. A basic premise of environmental risk management is that regulatory compliance is an insufficient indicator of pollution liabilities. That is, liabilities are more likely to result from exposures that fall outside of environmental regulations. A complete environmental risk management approach involves the scientific disciplines necessary to evaluate the full spectrum of the environmental risk: toxicology environmental science, environmental engineering, hydrogeology, and meteorology.

In the assessment of environmental liabilities, it is often necessary to evaluate each facility separately. Four individual factors should be evaluated: environmental routes, target populations, facility operations and practices and characteristics of materials. Each factor and the overall risk are evaluated for their potential to cause sudden impairment and nonsudden impairment. The overall risk is based on the integration and interaction of the four factors. Qualitative ratings are generally assigned, such as low, low-to-moderate, moderate, moderate-to-high and high. An essential part of any environmental assessment is the consideration of recommendations to better identify risks (such as further testing or monitoring) and to reduce risks.

An environmental assessment is extremely valuable to corporations in evaluating the impact of reduced availability of pollution insurance. It also enables a corporation to take a proactive approach to reducing risks. Environmental assessments are also required by insurance companies before a pollution insurance policy is issued. It is apparent that environmental risk assessment can be a useful tool to both corporations and insurance companies.